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THE DEVELOPMENT OF RAILWAY WATER SUPPLY PRACTICE[1]

By C. R. Knowles[2]

Railway water supply is a department of railway operation of vital importance. The handling of millions of passengers and billions of tons of freight requires adequate facilities, not the least of which are dependable supplies of good water at strategic points. There are 60,000 locomotives on American railroads. In 1929 they ran 1,330,000,000 miles and consumed 350 billion gallons of water out of a total of more than 500 billion gallons used for all purposes. As a result of these requirements, railway water supply has come to be a highly specialized branch of railway operation, and the more important railroads now have established departments charged with the responsibility for the development, construction and maintenance of all facilities pertaining to water supply.

HISTORICAL

In the early days of our railroads the question of water supply did not present serious problems either of quantity or of quality. Streams and ponds along the right of way afforded an ample supply, and the character of the water was given little consideration. The first locomotive tenders were simply barrels mounted on trucks, and

[1] Presented before the St. Louis Convention, June 3, 1930.

[2] Superintendent, Water Service, Illinois Central System, Chicago, Ill.

the water was fed to the boiler through a leather hose. The barrels were filled with buckets from such roadside supplies as were available.

In the purchase of the first locomotive used on the Baltimore & Ohio, one hundred years ago, it was specified that the total weight should not exceed $3\frac{1}{2}$ tons, and that it must be capable of drawing 15 tons, including the weight of wagons, at a rate of 15 miles an hour. As a comparison, the weight of the water alone in locomotive tenders today is often more than four times the total weight of the locomotive and loaded trains of one hundred years ago.

It was not until 1840, or ten years after the operation of the first locomotive, that storage of water was provided in tanks alongside the track. Water was delivered to the engine tender from the first roadside tanks through a leather spout, and it was another ten years after the introduction of roadside tanks before the leather was discarded for the metal spout. The original roadside tanks were barrels or hogsheads on elevated platforms. These were later succeeded by rectangular and round tanks of limited capacity. The size of the tanks gradually increased, and in 1870 we find tanks of 15,000 gallons used extensively. At the close of the last century the size of roadside tanks in common use ranged from 50,000 to 60,000 gallons, and in some few instances as much as 100,000 gallons. New locomotive tenders have capacities of up to 23,300 gallons, and tanks of 100,000 gallons are standard on most railroads; 200,000-gallon tanks are also used, and tanks with a capacity of one-half million gallons are not unusual.

The first roadside tank ever constructed was supplied with water by gravity. Most of the other early tanks were supplied either by buckets or by hand pumps operated by switchmen or other employees when they were not engaged in regular duties. The hand pumps were later followed by pumps operated by horse power, and the horse-power pumps were in turn replaced by windmills and hot-air engines. As the demand for water increased, steam pumps were installed. Many of these were later supplanted by gasoline engines. The gasoline and steam-driven pumps predominated up to twenty-five years ago. Now pumping equipment consists very largely of oil engines and electric-driven pumps.

TREATMENT

There is no place where the quality of water used is of more importance or where the correction of poor water conditions is more difficult

to accomplish than in a locomotive boiler. This is because the locomotive moves about and must be supplied with water from so many different sources and of such widely different characteristics. One solution of the problem of providing good water for locomotives would be to treat all waters uniformly. Unfortunately this is not always possible, not only on account of the expense involved, but also for the reason that even with the best treatment it would be impossible to secure a uniform quality of water. Water for locomotives is treated either in complete treating plants or by chemicals applied to the water as it enters the boilers at more than half of the thirteen thousand water stations in use on American railroads. A total of approximately two hundred billion gallons of water is treated annually. Something like sixty or seventy billion gallons of this water is completely treated with lime and soda ash in thirteen hundred treatment plants. It is estimated that these plants alone are removing one hundred and twenty million pounds of scale annually. If this scale were allowed to enter the boilers, it would add more than twelve million dollars a year to the expense of locomotive operation and maintenance.

The railroads in the western part of the United States have led in the treatment of boiler waters, for it is in this territory that it has been possible to show the most marked improvements. However, the benefits of treatment poor water supplies, both in the maintenance of locomotives and in improved operating conditions, are becoming more generally recognized throughout the entire country. For many years most of the waters in the eastern part of the United States were considered satisfactory without treatment. Within recent years, however, a good many Eastern railroads have inaugurated extensive treatment programs, and present indications are for continued development in water treatment on the railroads of the East.

Naturally the worst waters have received first attention, for the less troublesome waters, while costly from the standpoint of fuel economy and boiler maintenance, did not interfere seriously with train operation. As treatment has been extended to include most of the very bad waters, the water that was considered fair a few years ago has become the poor water of today. The value of water treatment is well established through records of savings in boiler repairs, fuel economies and reduction of engine failures. As train loads become heavier and boiler pressures are increased, it is apparent that treatment must be extended to include these waters of so-called

fair quality. The cost of providing adequate motive power for the movement of trains is constantly increasing. With investments of from $75,000 to $100,000 each in locomotives, poor water conditions can no longer be tolerated. Long engine runs are another factor in locomotive operation necessitating better water conditions. Better water is not only an economic necessity; in many cases it is an actual operating necessity.

The records of two railroads operating through poor-water territory in a Middle Western state are examples of the value of water treatment in improving train operation. Prior to the treatment of water, engine failures were common. In a single month, 108 engine failures occurred on a 300-mile division of one road; 91 of these failures were due to leaking flues. These failures affected 145 trains from one to four hours each. Another road operating in the same territory reported 583 engine failures on one division in eleven months. Treatment of water on these two railroads improved water conditions to such an extent that today an engine failure is almost unknown.

CORROSION

Much attention has been given to the pitting and corrosion of tubes and sheets of locomotive boilers. Substantial progress has been made toward the solution of the problem, especially on roads where the matter has been handled by trained water-service men. Numerous instances might be given where improved water conditions have corrected these evils. In measuring the results obtained, we are often inclined to overlook the fact that the chemist and water engineer is confronted not only with existing problems but with others that are constantly arising due to changing operating conditions and changing sources of water supply. If boiler sizes, pressures and ratings had remained stationary and the water supplies of a known character, the complete answer would have been forthcoming and the problem solved to the satisfaction of all. Boiler sizes, pressures and duties have constantly increased. As the country has been built up, water supplies of a satisfactory quality have become more and more difficult to obtain. The quantity required is much greater, and many of the available supplies are diminishing and are being subjected to ever increasing pollution from industrial waste. Added to these problems are the changes in the class of material used in the boilers and the methods followed in their construction. Conditions are constantly changing, and as soon as one problem is solved another takes its place.

Nearly all causes of corrosion are known, as well as the remedy, and such confusion as may exist in the minds of those seeking a cure for boiler pitting and corrosion is largely due to improper application of known remedies, or in other words an attempt to arrive at one particular cure for all forms of corrosion. The causes of pitting and corrosion are almost as many as the ills of the human body, and it is quite as reasonable to expect one standard prescription to cure all human ailments as it is to look for a universal cure for corrosion.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

The work of the Water Service Committee of the American Railway Engineering Association in the development of water treatment on American railroads is a fascinating story of human interest, notable not only for the results accomplished, but also for the lesson it teaches as to the need of proper application and understanding of scientific discoveries. Through the efforts of this committee, the practical value of treating locomotive water supply has been demonstrated beyond question. This committee was the first to establish the value of boiler-water treatment based upon the solids removed. It was also the first to establish standard methods of water analysis for boiler feed waters, interpretation of results and specifications for chemicals used in water treatment. While it is true that water treatment in some form or other is as old as boilers themselves, the Water Service Committee of the American Railway Engineering Association is undoubtedly the pioneer in its extensive application during the past twenty-five years.

This committee was one of the fourteen original standing committees formed at the time the association was organized in 1900. It is a tribute to the founders of the association that they had the foresight in the beginning to organize a committee to deal with the important subject of water supply. Through the work of this committee there has been made available a vast fund of information on the subject of railway water supply.

At the time this committee was formed there was but little information available on the subject of railway water supply, and the treatment of boiler feed waters was in its infancy. The published proceedings of the association carry more than 1,000 pages in the form of reports and discussion, and over 200 pages of monographs and special reports. The manual now contains 100 pages of recommended practice pertaining to railway water supply, including definitions, general principles of railway water supply service, such as

quantity, quality and sources of supply, and recommendations as to pumping equipment and conditions under which it should be used.

The manual also includes a recommended railway water department organization and deals with the treatment of boiler waters, standard methods of water analysis and interpretation of results, and the design, installation, operation, maintenance and supervision of water-treating plants, together with relative economy of plants and re-agents used. Specifications have been established for soda ash, hydrated lime, quicklime, sulphate of alumina and sulphate of iron for use in water-treating plants. The manual also carries complete detailed specifications for wood and steel tanks and various standard forms as used in railway water service.

This committee functions through sub-committees reporting to the general committee at the several meetings held throughout the year. Definite subjects are assigned to the committee for study and report. As an example this year's work of the committee includes the following studies; revision of the manual; pitting and corrosion of locomotive boiler tubes and sheets; the relative cost of eliminating impurities in locomotive boiler water supply and value of treatment; simplification and standardization of equipment and materials used in railway water service; automatic and remote control of pumping equipment; development of deep well pumping equipment; design and maintenance of track pans; protection of pipe lines from electrolysis; economy and effectiveness of various coagulants used in softening and clarifying water for use in locomotive boilers; chemical control and general supervision of water softening plants; protection of boilers and boiler materials from corrosion and deterioration while in storage; progress being made by Federal and State authorities on regulations pertaining to drinking water supply.

NATIONAL BOILER FEED WATER COMMITTEE

In 1923 a group of engineers and chemists interested in the treatment of boiler feed water inaugurated a study to improve methods of treatment of boiler feed water and to effect greater economy in power plant operation and in steam railroad service. A definite organization was established at the meeting of the American Water Works Association in New York City in 1924, and the first formal meeting of the committee at which various reports were presented was held at the power session of the convention of the American Society of Mechanical Engineers in New York City in 1926.

Six national technical organizations are coöperating with the committee in a study of the various processes employed in the purification of feed water in steam power plants and on railroads. This research is intended to determine the fundamental principles underlying certain phenomena which take place in steam boilers and methods for control. The committee is sponsored by the American Boiler Makers Association, American Railway Engineering Association, American Water Works Association, National Electric Light Association, American Society for Testing Materials and the American Society of Mechanical Engineers. The committee has been subdivided into nine sub-committees and an advisory committee. Each sub-committee has collected data relating to the subject assigned to it. This information together with progress reports have been submitted at various meetings held during the past four years.

The most important work of the committee has been the inauguration of the proposed research program to be carried on as soon as funds are available for these studies. It is proposed to carry forward the work in close coöperation with state and federal bureaus equipped for such work or at universities where engineering problems of a similar nature are in progress. By such procedure there will be required a minimum expenditure for equipment and other necessary facilities. Progress in the work has now reached the point where if it is to continue funds must be obtained to carry on paid research work essential to the successful solution of the problems involved, which are: (1) Priming, foaming and allied problems; (2) surface condensors, evaporators, deaerators, feed water heaters and piping; (3) corrosion of boilers, super-heaters, economizers and steam piping; (4) embrittlement of boiler steel.

The committee has given careful consideration to the financial requirements of the work outlined above. A fund of $300,000 should be raised to carry this work to a successful conclusion, this amount to be expended over a five-year period in equal amounts of $60,000 per year. The work of the committee indicates clearly that money spent in this form of research will result in improved operating conditions and will net a substantial return on the investment.

There are many points of common interest between railway and public water utility officers. Both have their problems of selecting and maintaining an adequate supply of water, the design and construction of pumping plants, pipe lines and storage facilities and the common problem of plant management. There is, of course, the

difference that the public water supply officer is usually concerned with one large supply while the railway officer has to provide hundreds of smaller supplies over many thousands of miles of railroad. They both have problems of purification, the public water supply officer being chiefly concerned with the purity of the water from the standpoint of human consumption and to a lesser degree with the problems of water softening. The chief problem of the railway water supply officer's softening the water and making it fit for use in locomotives. He is also concerned with the purity of water furnished for drinking purposes on trains and to employees. This problem has been solved to some extent by the improvements of the public water supplies from which train supplies are drawn.

The high standards of purity for waters furnished in interstate traffic, which are even more exacting than for a city supply, have added to the problems of the railway water supply officer. At the same time the public water supply officer has been faced with the increasing demand for softer public water supplies, which has brought them closer together.

The use of public water supplies by railroads is another point of contact. Probably one-third of the railway water supply is purchased from cities and towns along the line of road. Changing conditions have brought the railway water supply officer and the public supply officer closer together, and there are but few problems of water supply that are not common to both.

DISCUSSION

J. B. Wesley:[3] The subject with which this discussion treats has been presented to you with exceptional clearness and completeness. There is little that can be added to what Mr. Knowles has said and no explanations are needed. However, since Mr. Knowles has presented the subject from the standpoint of railroads of the country in general, it shall be my effort to show you how one phase of the subject, the treatment of boiler waters, has been developed on the road with which I am most familiar, the Missouri Pacific, and the benefits derived therefrom.

The Missouri Pacific traverses nine of the mid-western states. There is great difference in the quality of water supplies that must be used on a railway system extending into such diverse territories.

[3] Engineer, Water Service, Missouri Pacific Railroad Company, St. Louis, Mo.

The coal fields of Illinois give waters of an acid nature; the plains of Kansas and Colorado contribute waters that carry hidden quantities of gyp and alkali; the Missouri River and smaller streams of Missouri and eastern Kansas and Nebraska carry great quantities of mud; and deep wells of the southern states furnish soft soda waters. With such variety in the water supply quality there was soon noted a difference in train operation on the different districts; train delays occurring on some districts, short life of flues and fire-boxes on others, excessive fuel consumption on still others.

Confronted with such a diversity of water conditions, the Missouri Pacific early became a pioneer in the development and installation of treating facilities for water supplies. First, a complete survey of boiler water supplies being used and those available was made. Many supplies then in use were abandoned and new supplies were developed. Where a better supply could not be developed economically proper treatment was necessitated. Complete water softening plants, using lime and soda ash, were installed in 1905 at five of the major terminals and at a number of the intermediate stations between Poplar Bluff and St. Louis, St. Louis and Bush, Illinois, Kansas City and Pueblo,—about 32 plants in all, which treated approximately 14 percent of all boiler water. At that time chemical proportioning devices were not highly developed, often they failed to function properly, there was much prejudice and opposition on the part of some officials and many of the employees to the use of softened waters, and all too often there was not proper chemical supervision to secure constant and satisfactory operation of the plants. As a result, further development along this line was slow. However, a summary for the year 1909 showed the following: Water treated, 312,234,000 gallons; scale removed, 591,000 pounds. Compared to the year 1905 there had been a 44.7 percent reduction in engine failures due to leaking boilers and a 33.3 percent reduction in boiler maintenance. In view of these results additional plants were installed on the bad water districts north and west of Kansas City. In 1917 eight more were placed in service between Hoisington, Kansas and Pueblo, there being in operation at the end of the year 52 plants.

Development and extension of this work has continued. The annual report for the year 1929 shows 85 treating plants were operated; 3,247,000,000 gallons, or 46 percent of the total boiler water, was treated; 7,012,000 pounds of scale-forming matter was removed from the water before it was delivered to the boilers. It is estimated

that the net saving to the road, after deducting cost of chemicals used, maintenance and operation of the plants, and interest and depreciation on the investment in facilities, amounted to $686,000.00 for the year.

To date our water treating work has produced gratifying results, which is reflected in locomotive performance. The life of flues and fire-boxes has been materially extended, being doubled and tripled on some districts; boiler maintenance has been reduced correspondingly; fuel consumption has been cut; and train delays on line due to bad water conditions have been reduced to a minimum In 1918, on the 7450 miles of operated road, there were 547 locomotive failures due to leaking and corroded condition of boilers; in 1929, on the same territory and mileage there were only 3 locomotive failures from the same causes. During the time this improvement in operation was being made there has been material improvement in the construction and maintenance of boilers, and it is not claimed that improvement in water qualities alone has been responsible for the results noted above. But it is contended that the improved water conditions contributed largely to it and no such record could have been made without extensive and correct water treatment.

C. H. Koyl:[4] The cause of corrosion under water and the nature of the chemical reactions which accompany it have been known only a relatively short time. It formerly was maintained that only acid water could detach atoms of iron from a flue, and only in 1903 did Whitney at the Massachusetts Institute prove to the satisfaction of everyone that iron will dissolve in water without the aid of acid. That was the one bit of proof necessary to establish the correctness of the theory of electrolytic action as the cause of pitting and other forms of boiler corrosion.

The statement of the case now is that the purest iron will dissolve to a small extent in the purest water; that the purest iron which has ever been made dissolves more rapidly at some points than at others; that the atoms of iron which leave a flue in the process of making a pit all dissolve in the surrounding water and each atom carries with it its electric charge; that no electrically charged atom (ion) can enter water in solution without expelling from solution at

[4] Engineer, Water Service, Chicago, Milwaukee, St. Paul and Pacific Railroad Company, Chicago, Ill.

some other point an electrically charged atom (ion) of some other substance of weaker solution tendency; that the only substance in solution in ordinary water which has a lower solution tendency than iron is hydrogen, and that therefore iron can dissolve in water only when it can force out a corresponding number of electrically charged hydrogen atoms, or ions.

This at once gives us the key to the prevention of pitting. It is easy to see that if iron cannot dissolve in water unless it can expel hydrogen ions, all we have to do is to prevent the escape of hydrogen ions and we prevent the pitting.

It is also easy to see that if we can rid the water of hydrogen ions by some inexpensive method, *that* is the simplest means of preventing corrosion, because if there are no hydrogen ions in the water there is nothing for the iron to push out, and the iron cannot dissolve. Now it happens that the presence of caustic soda in water prevents to that extent the presence of hydrogen ions, and the amount of caustic soda necessary is easily within the limits that can be carried in boiler water that is soft. It seldom exceeds fifteen grains per gallon as the water goes to the boiler, and seldom exceeds eighty grains per gallon as the water becomes concentrated by continued evaporation. On the Great Northern Railway this is the method used and it has almost annihilated pitting on that road. Of course, it costs something to add fifteen grains per gallon of caustic soda to boiler water but it is cheaper than to repair the ravages of pitting.

When the hydrogen ions, or electrified hydrogen atoms, are pushed out of solution they gather in the form of a film of molecular hydrogen on the iron surface which is not pitting, each hydrogen ion having given up its electric charge to the iron merely by touching it, and if there is any method of preventing the hydrogen ions giving up their electric charge they will remain ions and cannot be pushed out of solution in the water. On the Chicago and Alton Railroad, the chemical engineer devised a very ingenious method of doing this. He coated the inside of the boiler with metallic arsenic whose electric properties are such that hydrogen ions cannot give up their electric charge to it, and, therefore, they remain in the water as ions, and the iron cannot dissolve because it cannot push them out. This method has been in use on the Chicago and Alton for four years and is now being extended to other roads. This method also costs perhaps one hundred dollars per locomotive per year, but that is cheaper than pitting.

The third method was devised and proved by myself and I consider it the best because it costs nothing and actually saves money in locomotive operation. You will remember how the hydrogen ions, expelled from the water by the dissolving iron, gather on the other parts of the boiler interior, give up their electric charge to the iron (becoming thus mere molecular hydrogen), and cling to the iron because they are too small to float away, thus gradually but quickly forming a gaseous film over the cathodic iron surface, which protects it from the approach of the hydrogen ions which are being pushed toward it from the anodic surfaces where pitting is going on. It is easy to see that such a film, one of the natural products of the first pitting, prevents further pitting by preventing the further escape of hydrogen ions. But this protection does not last, because the oxygen which is dissolved in all waters which have been exposed to the air combines chemically with the hydrogen and destroys the film. But also the extraction of this dissolved oxygen before the feedwater reaches the boiler is all that is necessary to the permanence of the protecting film of hydrogen, and to the prevention of pitting. On the Chicago, Milwaukee, St. Paul and Pacific Railroad we attach to the outside of the locomotive boiler an "open" feedwater heater so constructed that the cold water from the engine tank is pumped into one side of the cast iron box in a fine spray to meet the exhaust steam from the cylinders (which ordinarily goes to waste in the atmosphere). It becomes heated thereby to a temperature of about 220° and, therefore, gives up its dissolved air to the half-inch vent pipe which rises from the top of the box.

Some of you will remember that in a stationary boiler and its connections it is necessary that the dissolved oxygen in the feedwater be reduced to 0.05 cc. per liter to prevent corrosion. But conditions in a locomotive boiler are different because of the surging of the water and the tumultuous boiling, which is ten times as rapid as in a stationary boiler, and it was estimated and proved in a four years' test on the Sioux City Division of the Chicago, Milwaukee, St. Paul and Pacific Railroad that an average reduction of oxygen to one cc. per liter is sufficient.

This Sioux City Division has been our worst pitting district, for, with natural waters, the life of a set of flues used to average less than one year, with treated waters the average life was two years, but the engine with the open feedwater heater had not a pit at the end of four years.

The reason I say this is the best method of preventing pitting is that by utilizing the exhaust steam to heat the feedwater we save about 10 percent of the coal and water. A locomotive of average size uses about $20,000 in coal per year, and, therefore, while we are preventing pitting by this method we are also saving $2,000 in coal per engine per year.

FOAMING

Foaming in a locomotive is principally an operating difficulty, that is, it weakens the power of the engine, but it seldom injures the boiler. For many years we have wondered whether the matter suspended in the water in the boiler or the sodium salts dissolved in the water is the primary cause of foaming, because we know that both are factors. But at last we have concluded that it is the matter in suspension, and if you have not studied the subject you will be surprised when I explain that it is because dirty water is stronger than clean water.

You know that if you sprinkle water on a clean floor the water spreads almost uniformly over the floor. This is because the cohesion of the water particles among themselves, which is sufficient to keep the water in the form of round drops when it is falling through the air, is not sufficient to keep the water in drops against the cohesion between the water and the floor. But if the floor is covered with dust you notice that the water remains as round drops coated with dust, because the skin surrounding the drop is made up partly of water and partly of dust and this skin is strong enough to hold the inclosed water against the attraction of the floor.

One of our railroad water engineers tells how, in 1918, he was testing the size of soap bubbles which he could blow from an inverted pipe bowl, and he discovered that dirty water made larger bubbles than clean water, because the thin skin of water surrounding the inclosed air was stronger if the water was dirty; and he announced in the A.R.E.A. Report of 1919 "Foaming is due primarily to the presence of suspended matter in the water. The suspended matter gives a mechanical strength or tenacity to the liquid in the thin films encasing the steam bubbles, which, rising to the surface, retain their films and collect to produce foam." And about this time a witty and facetious man labeled these large and dirty bubbles "armored froth," but they are generally called "stabilized films."

Now consider the water in a working boiler. Bubbles of steam are being continuously formed and given off from the heating surfaces. These bubbles of steam are rising steadily to the surface of the water and, if the water is clean and reasonably pure, the bubble-skins break easily and the steam escapes to the upper part of the boiler almost dry.

But if there is dirt in the water, such as finely divided scale or sludge from a softening plant, then the particles of dirt are mixed with the water to its very surface and some of them are in the thin film of water which surrounds each bubble of steam, so that the bubbles accumulate on the water surface and get so high in the boiler that, when they do break, some of the water goes over with the steam.

And a still worse effect is that, by clogging the surface of the water, the bubbles appear to prevent the speedy issue of other bubbles, so that the water is gradually filled with bubbles and the surface rises, leading the engineman to believe that he has a boiler of solid water when he was only a boiler of froth.

PREVENTION OF FOAMING

Lastly, why does this foam disappear when a little castor oil is admitted to the boiler? If you allow a few small drops of castor oil to rise through a glass of dirty water you will find that the little drops of oil have stolen from the water much more than their share of dirt, and this greater affinity of dirt for oil than for water explains why a little castor oil on the surface of the water steals away the dirt from the steam bubbles and allows them to break promptly and to release practically dry steam.

PRIVATE CROSS-CONNECTIONS AND SIMILAR MENACES TO PUBLIC WATER SUPPLY QUALITY[1]

By Joel I. Connolly[2]

The dangers of cross-connections between a drinking water supply and an impure supply have been recognized for years and measures have been taken by water-works and public health authorities to guard against them.

The pollution of water by drainage or siphonage from fixtures having submerged inlets and by siphonage from waste pipes is a similar manace to health. The presence of this danger is easily demonstrated in almost all buildings of large size and frequently in smaller ones. The increasing use of fixtures where such pollution is possible has made the correction of the existing conditions necessary and the longer the matter is put off, the more difficult will the task become.

In order to simplify the question before us, let us consider the following items:

1. Every plumbing fixture directly connected to a waste pipe or stack in the plumbing system is a part of that system, and the sewage may back up into the fixture in case a stoppage occurs.

2. Water held in fixtures and traps may be contaminated in the course of their customary use, as well as by backing up of sewage.

3. If the water inlet to the fixture be submerged in such contaminated water or sewage, the reduction of the water pressure in the inlet pipe to a value lower than the static head will cause, upon opening the inlet valve, a return flow of the fixture contents into the drinking water supply pipe.

4. Self-closing valves actuated by the water pressure in the supply pipe, such as the common types of flush valves for toilets, become self-opening valves when the positive water pressure becomes changed to a negative pressure or partial vacuum.

[1] Presented before the St. Louis Convention, June 3, 1930.

[2] Chief, Bureau of Sanitary Engineering, Department of Health, Chicago, Ill.

5. The partial vacuum in a supply pipe is a common occurrence in many localities, due to (*a*) excessive use of water at lower elevations, (*b*) insufficient pumping capacity, (*c*) heavy draught upon fire hydrants in the vicinity by fire engines, (*d*) shutting off the supply while making repairs, and to other common occurrences.

6. In large buildings, especially, there is no ready means for the user of a fixture to determine definitely in advance whether a positive pressure or a partial vacuum exists in the supply pipe. The valve is opened and if there is no pressure, one simply waits for water. In large areas of Chicago this condition exists upon the third floors of many buildings during the hours when lawns are being sprinkled on warm days.

SUBMERGED INLETS CLASSIFIED

Submerged inlets to fixtures may be classified into two major groups, as follows:

Class 1. Inlets constantly submerged beneath the surface of the fixture contents when the fixture is in normally good operating condition.

Examples of Class 1. Siphon jets in water closet and urinal traps; steam tables; laundry washing machines; swimming pools; instrument sterilizers; jets in bottom of water-closet bowls used for washing bedpans; bell supply bath tubs, including therapeutic tubs; water baths for many purposes; hydraulic lifts; processing tanks; heating boilers; Bidet fixtures; filters; softeners; stock-watering basins.

Class 2. Inlets not ordinarily submerged beneath the surface of the fixture contents, but which at times become submerged due to carelessness in filling or to stoppage of outlets.

Examples of Class 2. Flushing rim openings in water-closets, urinals and slop sinks; lavatories; bath tubs; utility room sinks; dish-washing machines; spray heads in air washers; drinking fountains; bed-pan sterilizers.

These examples do not comprise all submerged inlet fixtures but serve to illustrate the differences between the groups.

When fixtures in Class 1 receive human excretions, as in the case of water-closets, urinals and sometimes therapeutic tubs and Bidets, or receive articles carrying infected matter, such as instruments and pus basins when placed in an instrument or utensil sterilizer having a bottom supply, the greatest precautions should be taken to prevent the entry of the fixture contents into the drinking water.

A flush valve not equipped with a vacuum-breaking device is useless for the purpose of preventing siphonage, because the creation of a partial vacuum in the supply pipe immediately opens the valve. The usefulness of any vacuum breaker upon a flush valve depends, first, upon the valve being closed when the partial vacuum is produced, and, secondly, upon the ability of the device to pass enough air to prevent the formation of a vacuum in the compression chamber of the valve, which, if formed, would open the valve and permit siphonage. The presence of foreign matter lodged on the main seat of a flush valve, the failure of a cup leather on a piston-type valve or the stoppage of the openings in the vacuum breaker may result in a condition permitting the contents of a toilet bowl to be siphoned into the drinking water supply.

THE MENACE TO STERILE WATER SUPPLIES

For many years surgeons have sought for the cause of post-operative infections. Some factors were discovered and eliminated but still infections continued, sometimes in explosive outbreaks strongly suggesting an undetermined common means of infection. Two years ago Dr. Arnold H. Kegel, commissioner of health of Chicago pointed out in an unpublished paper before the Illinois Medical Society that the infection of the water supply by siphonage from a bottom-supply instrument sterilizer, followed by the leakage of the germ-laden water into the sterile water tanks through a defective valve, would account for these outbreaks. This was an observation of great importance because wound infections by hemolytic streptococci usually result in the death of the patient. Samples of water taken from sterile water taps during an operation were examined and found to be unsterile, even though at the time of collecting the samples, the water was being used by the surgeon in the belief that it was safe to use. The cycle of transmission of the organism from an infected wound to clean wounds in other patients, via instruments, water in sterilizer, thence into the water pipes and into the sterile water tanks and back to the operating table on lap sponges, irrigating salt solutions, surgeon's rubber gloves, etc., is very direct and no doubt is responsible for the explosive character of the outbreaks of infections.

DIRECT CONNECTIONS TO WASTE PIPES

An unbroken, or direct, connection from a water supply pipe to a waste or sewer pipe is not uncommonly found. Very frequently

filter or softener drains and wash-water wastes are directly connected to the house drain, in such a position that sewage may back up into the filter or softener during times of storm. Frost-proof closets, cooling coils in ice machines, water stills and water sterilizers are often found to have unbroken connections to waste pipes through which sewage could be siphoned into the water supply. In one instance, ammonia escaping into the cooling coil blew the water back into the street mains, and acting upon the bronze valves, colored the water blue with copper compounds throughout the neighborhood.

Drains to water stills and water sterilizers also are directly connected to waste pipes, in many instances. This is a pernicious practice, since the condensation of the steam to produce the distilled water, or after sterilizing the water, respectively, produces a partial vacuum which may easily suck sewage into the distilled or sterile water. Such a case has been observed, where the attendant thought she was distilling water at an unprecedented rate, but was actually siphoning sewage into the distilled water tank.

Priming connections to sewage pumps are occasionally found. In November, 1927, an epidemic of gastro-intestinal disease among one hundred employees of a large power house in Chicago was traced to a 1-inch connection for priming a pump handling polluted water.

Aspirators used for producing a suction in operating rooms, in dentists' offices and in laboratories are sometimes directly connected to the waste pipes. Recently a friend of the writer was performing a Caesarian section in a hospital in Omaha when a stoppage in the waste pipe produced a flow of sewage through the tube of the aspirator. The nurse noticed the sewage entering the bottle commonly used in the suction line to collect the blood drawn from the incision, and called the surgeon's attention to it only a few seconds before the sewage would have reached the wound.

THE REMEDY

It is much easier to find improper and dangerous connections to the water supply pipes than it is to tell just how to remove the danger. Numerous vacuum breakers and check valves have been designed and used. The best way, from the standpoint of entire safety, is to remove all submerged inlets to fixtures and all direct water connections to waste pipes.

If this cannot be done, it may be possible to have every riser open at the top to the air, so that no vacuum could ordinarily be formed

in the riser. Where there is a house tank, this can be done by having each riser (except the one supplying water to the house tank, of course) continue full size, uninterruptedly from a point below the shut-off valve, to an elevation above that of the water surface in the house tank, and end in an open return bend, to prevent things from dropping into it. As the riser is drained, air will enter the open end and prevent the formation of a vacuum.

Where there is no house tank, the formation of a vacuum in risers may be prevented by proper use of vacuum breakers. In either case, the branch leading from the riser to the submerged inlet should be carried up at some point between them to an elevation at least several inches above the rim of the fixture, so that the water will not drain back into the riser because of its own weight.

To eliminate all submerged inlets would mean to rule out flush valves and go back to the use of flush tanks for toilets. There are sound advantages in the use of flush valves, such as economy of space, and not having to wait between flushes, which make one hesitate to adopt so drastic a step. On the other hand, unless precautions are taken in the riser, as mentioned above, some protection at the fixture is essential, as it has been found that with certain types of siphon-jet bowls, it is possible to siphon from the trap of the closet through the jet opening, even while the rim openings are drawing in air.

A good vacuum breaker in the flush valve is of great value but most, if not all, of those now commercially available leave very little factor of safety for possible leakages past the cup leathers on the plunger, or for failure of the main valve to seat tightly. It is my tentative opinion, based upon unfinished studies, that with fixtures having inlets occasionally submerged (Class 2, as described above), and for use with a filtered water, or in places where the creation of a partial vacuum is very improbable, the best of such built-in vacuum breakers in flush valves may prove to be a practicable remedy, provided the valves are properly serviced and kept in good condition. For Class 1 inlets, that is, those constantly submerged, and in places where siphonage occurs frequently, some additional protecting device, or a larger air capacity than that of the built-in vacuum breakers in flush valves now on the market, will probably be required for adequate protection.

Certain special types of rubber-faced check valves also may prove, upon further investigation, to give adequate protection to flush valve

connections for occasionally submerged (Class 2) inlets when used with a filtered water supply, or when used in places where the creation of a partial vacuum is very improbable. A combination of a check valve and a vacuum breaker of adequate size to prevent a vacuum in case the check valve is held open by débris lodged in it, appears to be the safest available solution of the flush valve difficulty when such valves are used with constantly submerged (Class 1) inlets and with an unfiltered water supply or in a location where siphoning is frequent. Preliminary tests by the writer indicate that it is possible to have large obstructions in the check valve and flush valve, holding them both open simultaneously, and still prevent contamination, by the use of a properly designed and adequately sized vacuum breaker in the water supply pipe on the fixture side of the check valve. Further tests are now being made to determine the effect of the passage of time upon these devices.

On lavatories, and bath tubs, the inlets should be placed above the rim of the fixtures. Seldom will the overflow openings in such fixtures be found to be large enough to carry off the water as fast as it enters. Where it may be necessary for any reason to have a bell supply, as in a therapeutic tub, special attention should be given to the provision of some adequate device to prevent the formation of a vacuum in the supply pipe, such, for instance, as a combination of check valve and vacuum breaker mentioned above.

Direct water connections to waste pipes should be cut off and the water discharged into a funnel or pipe of larger size, properly trapped. The end of the water pipe should be above the funnel rim.

CONCLUSIONS

To prevent water pollution through submerged inlets to fixtures and direct waste connections, all water pipe and waste pipe installations must be more carefully supervised. Manufacturers must join forces with water works and health authorities to develop safer fixtures or provide protective devices to prevent back pressure and siphonage. All direct water connections to waste pipes should be severed. Whenever possible, submerged inlets should be removed and the water should enter over the rim of the fixture. Where that is not possible, the purity of the water supply should be protected by an adequate non-siphoning device.

DISCUSSION

WM. C. GROENIGER:[3] In our experience it is a more difficult task to teach people to recognize improper and dangerous conditions than it is to remedy the condition itself.

We do not believe it is necessary or advisable to rule outflush valves or eliminate all submerged or underrim water supply inlets to plumbing fixtures.

Under no circumstances could we recommend or suggest a check valve as a remedy or as a preventative to prevent cross connections between a plumbing fixture and a water supply distributing system.

Plumbing fixtures are the terminals of the water supply distributing system, the source of sewage and the beginning of the sewerage system. Human excrement, urine, body and domestic wastes are not safe for human consumption. No person would knowingly drink water from a water closet, urinal, bed pan sterilizer, instrument sterilizer, lavatory, bath tub, laundry tray, dishwasher or soda fountain bar sink.

The point where safe water ends and sewage begins is sometimes very finely drawn and not always easily recognized.

Many well designed bath tubs, lavatories, sinks, laundry trays and water closet tanks have overrim nozzles, spouts or raised ball valves.

It is impractical, however, to use the overrim method of water supply in serving many types and kinds of plumbing fixtures. The efficient performance of various kinds and types of plumbing fixtures requires velocity and pressure. This means that the underrim water supply connection is the only practical method of introducing water into the fixture. It also means that the plumbing fixture with the underrim, integral or submerged water supply inlet should not be disqualified or condemned as such. It is a combination of this type of fixture with the location of the control valve and the installation of the pipe from the control valve to the water supply inlet that makes a cross connection possible.

The principle involved is that piping and inlet supply connections should be made to preclude the possibility of any waste water or sewage from the fixture returning to the water supply distributing system either by gravity or by siphonage.

Plumbing fixtures and their water supply connections may be placed in three separate groups.

[3] Consulting Sanitary Engineer, Columbus, O.

OVERRIM SUPPLY

When the water enters the fixture through an overrim nozzle or spout with several inches between the top of the fixture and the spout or nozzle there is no danger of any waste water finding its way back into the water supply system. Any spray connected with flexible rubber hose which may be submerged in the fixture itself will make, however, a temporary cross connection.

UNDERRIM, INTEGRAL OR SUBMERGED WATER SUPPLY INLET WITH CONTROL VALVE LOCATED ABOVE OR OVER THE FIXTURE

This type of fixture and connection makes possible the return of waste matter by siphonage.

The siphon in its various forms and siphonage has more uses in plumbing than any other apparatus. In order to study the subject of plumbing fixtures acting as cross connections one must have a clear understanding of siphon and siphonage; recognize them where they are built into a plumbing fixture or made up in the connecting of a plumbing fixture to a water supply distributing system.

There are two methods of installation that will prevent the waste water from any plumbing fixture returning to the water supply distributing system by siphonage.

The Venturi air intake valve

The Venturi method of air intake, located in the flush valve or between the valve and the fixture, is always open to the atmosphere and has no check nor ball nor any other mechanical device. The intake openings must be of sufficient area to supply air in quantities to prevent a partial vacuum and eliminate siphonage.

Air intake valve or vacuum relief valve

The air intake valve or vacuum relief valve must not be confused with a check valve or other mechanical devices, wherein the failure to function destroys its value as a factor of safety.

When located on the house side of the control valve between the underrim fixture connection and above or over the fixture, the air intake valve is positive in its operation. The air intake openings are open to the atmosphere at all times except when water is entering the fixture. Air is always available to break any partial vacuum that may occur in the water supply distributing system.

Air intake valves may also be installed on risers and branches, but care must be exercised not to isolate the siphonic effect to branches serving one or more fixtures where one fixture supply pipe will act as the siphon leg to suck waste water out of the other fixture. The function of air intake valves and vacuum relief valves is to allow air to enter in sufficient quantities to prevent siphonage but always prevent water leaving the pipe through the air intake openings.

UNDERRIM, INTEGRAL OR SUBMERGED WATER SUPPLY INLET WITH CONTROL VALVE LOCATED BELOW THE OVERFLOW POINT OR BENEATH THE TOP OF THE FIXTURE

This type of construction makes possible the return of sewage or waste by gravity. The practice described in this classification is without merit, reason, efficiency or economy. New installations should be prohibited and old installations corrected, condemned or removed. Old installations may be corrected by looping the branch supply pipe above the fixture and inserting a vacuum breaker or air intake valve at the top of the loop. Our investigations have brought to light drinking fountains with a bypass connection between the water supply pipe and the waste pipe making self pollution possible in this type of plumbing fixture.

Theoretically a check valve is a device by which a liquid will flow in one direction but the mechanical moveable part prevents a return flow. Experience and practice, however, teach that any device subject to hidden mechanical defects can not be approved as a preventative against possible infection, pollution or contamination of a safe water supply. We would not knowingly risk our life or the safety of our health to a check valve. Placing a check valve in a water supply pipe between the flush valve and the supply riser can not be recognized as a preventative against pollution.

The people in your city are living under the security of a safe water supply. The water is safe when it leaves the purification plant. Thousands of underrim water supply plumbing fixtures in each city may at any time pollute, infect or contaminate the water supply before it reaches the consumer. These are not theories. Tests, research and experiments have convinced many that they are real. At this moment they menace you and your children. Make no mistake. Safe water is personal. Personal to you and to all of us. And the penalty will be personal, too, if you pay the cost of indifference.

H. H. GERSTEIN:[4] Sanitary engineers should move slowly in their acceptance of mechanically operated devices as a positive means for prevention of back siphonage through directly connected fixtures. The majority of vacuum breakers in use today have the same disadvantage of check-valves, i.e., unless serviced often and properly they may fail to operate at a critical time, due to mechanical defects. The ideal way to prevent back siphonage would be by the use of a non-mechanical siphon breaker which can not get out of order or clog. This could be incorporated in the toilet bowl or in the flushing fixture, the area of the vent being equal to the size of the pipe opening. Under given conditions, the acceptance of certain types of check-valves and vacuum breakers may be advisable, to prevent contamination in existing installations. This acceptance, however, should be tentative only.

Mr. Connolly has thoroughly covered the various ways in which the public water supply may be contaminated through private cross connections. Public health officials are constantly coming in contact with new types of cross connections. Recently the writer came upon a cross connection of interest. Chicago supplies water to a certain community outside the city limits through a 24-inch main which crosses the Calumet River. A large leak in a section of the main under the river necessitated shutting off the water on the city side of the main, in order to make repairs. When this was called to the attention of the writer he made a sanitary survey of the water supply in this community and found it grossly polluted. The indications were that the contamination was caused by the entrance of the polluted river water through the point of leakage by the means of suction created by several pumps directly connected to the main, which continued to operate after the valve was shut off on the city side.

F. GARDNER LEGG:[5] Mr. Connolly has very ably covered the field of possible methods for polluting a public or private water supply with various piping arrangements and forms of fixtures in general use throughout the country. He has explained many different ways in which private cross-connections stand as a menace to the purity of a

[4] Sanitary Engineer, Department of Public Works, Chicago, Ill.

[5] Chief, Bureau of Sanitary Engineering, Department of Health, Detroit, Mich.

general water supply, and water work's officials may perhaps wonder why such fixtures and devices have been permitted to be used in view of the fact that such intensive measures have been adopted by the municipalities to insure that the purity of the water as it leaves the pumps at the municipal water works may be assured.

Officials that have been struggling with this problem for a number of years have probably arrived at the conclusion that one reason why such conditions have been found to exist is because too many departments have jurisdiction over the installation of plumbing and private water distribution systems, and that the designers of special appliances in which water is used for domestic conveniences have not taken into consideration the possibilities of pollution of the drinking supply lines by various types of so-called "Cross-Connection Devices." It is true that in some instances the possibility for pollution is quite remote, nevertheless, in the case of every device mentioned by Mr. Connolly, a careful analysis will show that his claims can be substantiated by practical demonstration under certain definite conditions and these definite conditions may be established somewhere at almost any instance.

As far back as 1926, when we were considering a revision of our Plumbing Code, the matter of private cross-connections was causing us some concern. At that time a letter was sent to fourteen of the largest cities in the country asking for information relative to their code provisions for prohibiting certain types of fixtures and connections similar to those mentioned by Mr. Connolly. The replies indicated that the officials in charge of plumbing realized the possibility of pollution by certain devices, but, in most instances, the codes made no provisions for prohibiting such devices. We realize how difficult it would be to set up such specifications as would exclude most of the fixtures in general use, but we did attempt to make a definite start in this direction by inserting the following paragraph:

Such fixtures as are so designed and arranged that the water is discharged into the fixture below the rim or overflow strainer or connection are prohibited, except in such cases where the supply lines are so arranged that there is no direct connection with the city service lines, or some approved safety device provided to protect against possible pollution of the supply lines, in instances where vacuum might be created in the same due to low pressure, or at such times as the lines are being drained. The above provisions shall also apply to all types of flush regulating valves and supply tanks connected with closet or urinal fixtures, and swimming pools.

This provision was not made retroactive, but has been applied to all new work installed since October 1, 1928.

It will be noted that this section calls for no direct connection with city service lines unless some approved safety device be provided to protect against possible pollution. In the approval of this safety device, we have no doubt erred by permitting the use of some apliances that will fail to function under certain conditions. We have, however, approved these with the understanding that they are an effort towards accomplishing ultimate desired results and that, with the coöperation of parties having interest in this particular problem, it may be anticipated that eventually some definite solution which can be universally applied will be incorporated into every plumbing code in the country. It is the writer's opinion that a properly designed vacuum breaker on the venturi principle may be the final solution of the problem, but radical change in the design of fixtures will be necessary before this can be accomplished.

I believe it is reasonable to assert that, although this question is of vital importance in every community, it will require some considerable time to secure the coöperation of all interests essential for the final solution of the problem. Though water works officials in general have no direct control over piping connections and devices inside of the property line, nevertheless, their influence in bringing about an awakening on the part of those officials having such jurisdiction in their respective communities presents a field for additional public service that is worthy of their active support.

S. B. Morris:[6] Mr. Connolly has brought the attention of the water works operators to a very serious menace to the quality of the general public water supply. Cross-connections within plumbing fixtures have passed unnoticed by health officials, sanitary engineers and inspectors and finally by the water works profession itself until but a few years ago. With all the attention that has been given to cross-connections with contaminated and other sources of supply, it is quite difficult to understand how such a flagrant offender as the plumbing fixture cross-connection should have remained so long undiscovered if not eliminated.

The paper just presented is so thorough that there is little to add other than approval and congratulations to the author who has so well brought this important matter to our attention. It may, how-

[6] Chief Engineer, Water Department, Pasadena, Calif.

ever, be worth while to further stress some of the facts brought out in the paper in order to give it greater impetus.

Practically all water works operators maintaining laboratories are from time to time confronted with positive B-coli counts from tap water while all sources of water supply and of stored water are negative. May not much of this trouble be with the plumbing fixture cross-connection?

It appears from Mr. Connolly's paper that an excellent opportunity exists in Chicago to test the extent of contamination in districts where water pressures frequently fall below the fixture level. Such actual and positive tests would be of great value in securing public support to correct faulty fixtures and connections already installed. No doubt we can all secure passage of regulations giving ample authority to correct future installations, but correction of present faulty fixtures involving material expenditures is much more difficult though equally necessary.

The manufacturers can truly be of the greatest assistance in working out a proper solution to the problem, and it should be distinctly to their financial advantage to do so, as properly designed fixtures should have a larger market, particularly in adding to the volume of replacement business. Flush valves of the equalizing-pressure type, now being placed on the market are a distinct improvement over the former type which in many cases would be opened by any vacuum occurring in the line. Their effectiveness, however, depends upon an air valve which may very likely fail owing to infrequent use. The small float may be held by a high pressure against the air orifice for years before it is called into action. Any successful air break should be without moving parts. Detailed discussion of such designs cannot be made in the few minutes allotted for discussion.

The City of Pasadena has during the past year, added to the Plumbing Regulation Ordinance, a new section being designed to regulate cross-connections as follows:

Section 35½. (a) *Fixtures Not Cross Connected.* No plumbing fixture, device or construction shall be installed, or shall be connected to the water supply, when such installation or connection may provide a possibility of polluting such water supply or which may provide a cross connection between a distributing system of water for drinking and domestic purposes and water which may become contaminated in such plumbing fixture, device, or construction.

(b) The inlet or inlets from the general water system on every plumbing fixture, device or construction shall be so placed as to be at all times above the level of the water held or stored in such fixture, device or construction and shall be placed above all outlet and overflow vents therein; provided, however, that the said requirements shall not apply to any fixture, device or construction equipped with any device which, without requiring moving parts, automatically prevents the back flow into the general water supply of any water held or stored in such fixture, device or construction.

These provisions are in addition to an ordinance forbidding cross connections with any other source of water supply, made a part of the Water Department regulations.

It is important to note such extreme observed cases as these. Contamination of water supply by priming of a sewage pump by a garden hose wired onto the sewage pump. In this case, raw sewage was discovered in the shower baths and drinking fountains of a public bathing pool. In another case, air was forced backward through the water meter from a garage to lessen the water bills. This latter was probably not serious in itself; but if air could thus be used, why not contaminated water?

The point I wish to stress is this, that, in spite of all regulations that can be adopted to eliminate cross-connections, accidental or even malicious contamination may occur by water forced or drawn back from consumers premises into the distributing mains. Complete elimination of possibility of such pollution is impossible. Only by the most active coöperation of all agencies of public health, sanitary inspection and public water supply, and by the manufacturers and plumbing houses, may we expect to reduce such hazards to a minimum.

THE ELECTRIC PUMPING STATION FOR NEW BRUNSWICK[1]

By Asher Atkinson[2]

The New Brunswick water supply was built by a private company in 1867. A mill property known as Weston's Mills, near the mouth of Lawrence Brook, about 2 miles from the center of the city was bought. The pumping station was built, the pumping main to a distributing reservoir was laid and a distribution system of pipes was provided.

The first station had a water power pump and a direct acting steam pump. For a number of years the water consumption was so little that most of the pumping was done with the water power, the steam pump being used only at times of low water.

Lawrence Brook has a drainage area of 45 square miles which would be ample to supply a large population if convenient and cheap storage basins were available.

The water is pumped to the reservoir a distance of 8000 feet and at an elevation of 123.5 feet above the pond level. A filter plant was constructed at the reservoir in 1917 and filtered water is pumped from this plant to a stand pipe 85 feet high for distribution to the city. The water is very soft and highly colored with vegetable matter dissolved from swampy areas in the water shed. The filter is of the rapid, gravity type and has a capacity of 8 m.g.d. The method of storage at the filter plant provides a means of securing a possible steady rate of pumping. The reservoir has a capacity of two million gallons in its upper part, which is available for the filtration plant, the clear well has a capacity of 400,000 gallons and the stand pipe of 800,000 gallons. By using these storage capacities both pumping station and filter plant can be regulated to give reasonably uniform operation.

The original pumping main was a 12-inch cement coated sheet iron pipe. This gave considerable trouble from breakage especially when

[1] Presented before the New York Section meeting, December 30, 1930.
[2] City Engineer, New Brunswick, N. J.

the single cylinder direct acting steam pump was used, but this was soon replaced with a larger cast iron main. From time to time the pumping main was enlarged until the present mains consisting of two lines of 20-inch cast iron pipe were installed.

From time to time additional storage has been added to the original mill pond. The first additions were made by increasing the height of the old original mill dam. As nothing was added to the bottom of the dam this method came to an abrupt end in 1888 by the whole dam going out one night. The pumping engineer noticed that his pump was not drawing water properly and on going outside of the pumping station building he found that the dam was gone. A temporary dam had to be built to get the water into the suction well and a permanent dam was constructed later in that year.

In 1918 an additional dam was built, adding $4\frac{1}{2}$ feet to the level of the pond and increasing the storage to double the original capacity. In 1926 an entirely new reservoir up the stream was built by a dam 300 feet long impounding 800,000,000 gallons. The total storage under control of the city is above a billion gallons, which is six months storage at the present rate of water consumption. This storage will be ample for some years to come and can be increased or, if more water is needed, some of the state's projects for joint water supply can be drawn on.

PUMPING EQUIPMENT

Having provided an ample supply of water the question of means of getting it to the filter plant in a reliable and economical way was urgent. The pumping station equipment had been changed from time to time and enlarged as needed until it consisted of a 6 m.g. cross compound pump installed in 1900, two 5 m.g. turbine driven centrifugal pumps installed in 1916 and a water power rotary pump of 3 m.g. capacity for use when water was wasting over dam. Two water tube boilers with combined capacity of 600 horse power furnish the steam.

For the last two years the cost of running at the steam plant has been steadily mounting until the operation is most uneconomical. The cost of repairs to boiler, engine and pump was very high and has been increasing, so a new pumping station was demanded, both for economy and reliability.

In designing the filter plant it was decided to have it electrically operated with purchased power. For the past thirteen years the

entire output has been pumped by electric motor driven centrifugal pumps. With the exception of a discontinuance of service at one time in 1918 due to the war conditions, there has been practically no interruption of service from the public service power lines. The labor cost of operation of these pumps has not caused any additional expense at the filter plant. The cost of pumping has amounted to around $8 per million gallons. This service has been so reliable and convenient that in selecting the type of pumping station at Westons Mills the electric drive has this point in its favor.

Before deciding finally on an electric station, the city had a definite understanding with the public service corporation that they would supply two independent power lines to the station. One of these comes from the City of New Brunswick substation over a wooden pole line, a distance of two miles and one comes from the Piscataway substation over the line of the main transmission on steel towers. The Public Service is tied in with neighboring power companies so that the possibility of a failure is very remote.

The present consumption of water is around 6½ m.g.d. average with a peak load of 11 m.g.d. for short periods.

The pumps selected for the station were an 8-inch centrifugal driven by a 200 horse power synchronous motor, with a capacity of 4 million gallons, two 12-inch centrifugal pumps driven by 300 horse power synchronous motors with a capacity of 6 million gallons each. One of the 12-inch pumps has a 250 horse power gasoline engine which can be coupled to the pump and operated in an emergency. The total capacity of the station is 16 m.g.d. at the highest head.

The water is pumped through the two pumping mains 8000 feet to the reservoir with a static head of 123.5 feet. The friction on the lines was determined by pitot tube measurements of flow through the mains with corresponding pressures and it was determined that the Hazen coefficient for the pipes was 73. The large amount of friction in the pipes makes the use of a centrifugal pump difficult for this service. In the design of impellers for the pump due consideration must be taken of the number of pumps in operation, for at times the head will vary from 150 to 220 feet under these conditions. The impellers of the pumps must be designed to give the required amount of water at the highest head and yet give a reasonable efficiency when delivering a great quantity of water at a lower head and also not to overload the motors at such times. The 12-inch pumps in the station show an efficiency of 77 percent at 150 feet

head, 84½ at 200 feet head and 82 at 220 feet head. This will insure a reasonable efficiency under the working conditions.

The motors which have been in use at the filtration plant for the past thirteen years are slip ring motors. The motors at the new station are synchronous motors. The Public Service Corporation makes no extra discount for the use of synchronous motors, but as many power companies do it is hoped that perhaps in the future there may be some allowance for their use.

The motors are operated by remote control from an 8 panel switch board. The panels are arranged as follows: No. 1 being the power company's meter panel, Nos. 2 and 3 are incoming line controls, Nos. 4, 5 and 6 are for the control of the motors, No. 7 is for the transformer bank and No. 8 is a low voltage panel, for lighting and small motors.

There are two-three phase incoming lines from two different sources. These come in through circuit breakers. The breakers are single throw oil switches with trip coil attachments. They are protected by disconnects both on the line side and on the station side. These circuit breakers are manually operated.

The motors are operated by remote push button control, the starting being by the reactance method. There are two sets of motor operated automatic oil switches for each pump motor.

The current is thrown on the exciter through a starting circuit breaker and through a starting reactor. When synchronous speed is reached the current is automatically thrown on the running circuit breaker which cuts out the starting circuit and applys full voltage to the motor.

The motor operated mechanism which controls the oil circuit breakers is run on 220 volt current through a rectox outfit and time relays.

The low voltage mechanism is operated through 3 to 5 Kv-a 4150 volt to 220 volt transformers. The lighting panel is controlled by a separate 1½ Kv-a 220/110 volt balance transformer.

There are a number of small motors about the plant and these are operated from the lighting panel.

All of the meters are controlled from a buss through a 40/1 fused potential transformer.

The plant is housed in a building 40 by 48 feet with exterior of Colonial brick with limestone trim. The roof is of rough variegated slate. The interior walls are lined with buff colored wall tile. The

floor is of dark red quarry tile laid in 6-inch squares with black mortar. The building is provided with a boiler room and is heated with an oil burner which is connected with two overhead fan heating units. The basement is utilized for main suction and discharge pipes. The reactors and transformers are also in the basement.

The contracts for the work were as follows:

Pumps and electrical equipment	$24,000
Building	21,730
Plumbing and heating	3,000
Electric lighting	865
Oil burner	945

The main suction and discharge pipings were done by the city force.

The suction pipe is a 30-inch cast iron pipe running from the pond to the station. The floor of the station is one foot below pond level so the normal suction is less than two feet. The discharge is a 24-inch cast iron pipe branching into two 18-inch pipes. These pipes were tapped into the two 20-inch mains under pressure. In making these cuts a good opportunity was afforded to see the conditions of the old pipes. They were very little corroded, but there was a solid growth of matter adhering to the pipe, one inch thick. This was found to be mostly fresh water sponge and accounts for the high friction in the pipe. There is a 24- by 14-inch venturi tube in the discharge connected with a register in the pumping station.

The cost of pumping with the steam plant has increased steadily for the past ten years. At that time some study was given to the matter of changing to electric pumping, but no great economy was apparent. In 1924 the cost of pumping had grown to $16 per million gallons and by 1929 this had increased to $26.80. The excessive cost is due to the growing inefficiency of the pumps, the higher cost of coal, the larger amount of labor and the excessive repairs.

The estimate for cost of pumping by electricity is $14.72 per million gallons. The total pumping in 1929 was 2285 million gallons, so the estimated saving of about $27,000 per year will soon pay for the improvement within a period of three years.

LEGAL PHASES OF MUNICIPAL WATER STORAGE[1]

By Malcolm Lindsey[2]

In a paper[3] which the writer read about a year ago before the Rocky Mountain Section of the American Water Works Association it was said that the system of Rocky Mountain water law "is still in the making; and there are many problems of water law yet to be solved." Since these words were written there is one problem which has become very acute, and on its solution will depend, to a very considerable extent, the methods which water users must take to provide for their water needs.

The problem in question is as to whether a junior direct appropriator may invade a senior storage appropriation.

To understand this problem and its importance it is well to remember that the development of the use of the waters of a stream has usually taken place in the following order:

First, the taking out of small irrigation ditches to water the bottom lands along the stream;

Second, the construction of large canals to carry the water out of the stream bottom and onto the bench lands;

Third, the building of storage reservoirs to conserve the flood waters for later use.

Where this general order of the development of the waters of a stream has been followed there are good results, because this order of development leaves the reservoirs with the junior rights. In other words, in such cases, the reservoirs only get what water the ditches and canals cannot use; and there can be no invasion of reservoir rights by the ditches, as the ditches must be supplied first, having the senior rights.

On most of our streams in the Rocky Mountain region the above mentioned order of development of the waters has taken place, that is: first, small ditches; second, large canals; third, storage reservoirs.

[1] Presented before the Rocky Mountain Section meeting, February 14, 1930.

[2] Attorney, Board of Water Commissioners, Denver, Colo.

[3] This Journal, May, 1929, page 609.

In time, however, on nearly every stream, we find that additional ditches are taken out. These later ditches are apt to be subsequent in construction to the reservoirs. When this happens, we have the important and vexing problem as to whether a junior direct appropriator may invade a senior storage appropriation.

The problem is complicated in Colorado by a statute (Sec. 1682, Comp. Laws, Colorado, 1921) which provides:

> Persons desirous to construct and maintain reservoirs, for the purpose of storing water, shall have the right to take from any of the natural streams of the state and store away any unappropriated water not needed for immediate use for domestic or irrigating purposes.

Taking this statute literally, it would seem to imply that a junior direct user may take water away from a senior reservoir.

The Supreme Court of Colorado has never passed directly upon this question, although in two decisions there are chance expressions which give much comfort to those junior direct appropriators who claim the right to take water away from senior reservoir appropriators. Many years ago, in Water Co. v. Tenney, 24 Colo. 344 it was said on page 351:

> It is scarcely conceivable that the district court would deliberately enter a decree giving to a reservoir owner any priority to fill his reservoir which would conflict with any right of a ditch owner to use water for irrigation, even though the priority of the latter was junior in time to the construction of the reservoir.

The words just quoted were spoken about thirty years ago. In a 1929 decision, Handy Ditch Co. v. Greeley Co., No. 12,127, Colorado Supreme Court, it was said:

> Obviously, the water commissioner can and must distribute water for direct irrigation according to the direct irrigation decrees; and water for storage in accordance with the reservoir decrees, when not required for direct irrigation.

Let us assume, for a moment, that the Supreme Court of Colorado literally meant that every direct appropriation is to be supplied before any water can be stored and let us see what the practical effect would be on the development of our western country.

We are accustomed to think of a direct use season and a storage season; and, in fact, in compiling our figures we usually divide the

year into an irrigation season of seven months from April 1 to October 31 and a storage season of five months from November 1 to March 31.

The Colorado Supreme Court, however, in the case of Comstock v. Larimer Company, 58 Colo. 186, decided in September, 1914, held that no arbitrary division of the year could be made and that changing conditions of need for diirect use of water would result in changing seasons.

As a matter of fact, if the year were arbitrarily divided into an irrigation season of seven months and a storage season of five months, the reservoir owners would suffer because, in most instances the streams do not carry enough water in the five months from November 1 to March 31 to fill the reservoirs. On the contrary there have usually been three seasons each year when reservoirs could impound water as follows:

First, the winter season when there is no irrigation;

Second, the time of the spring run-off when the melting snows produce more water than the irrigationists can use or desire;

Third, short periods usually in July and August when torrential rains produce sudden floods in excess of the capacity of all irrigating ditches.

Of course, there are years when there are no torrential rains in July and August and consequently no summer storage. There are also occasional years when there is no spring run-off sufficient for storage. This is sometimes due to light snow falls and sometimes to the fact that a cold spring makes the snow melt so slowly that it does not greatly raise the streams, in which case the irrigation ditches are able to and do take all the water.

Therefore there are some years when there is no opportunity for spring or summer storage; but in most years in the past reservoirs have been able to store during the winter, during the spring run-off and during summer floods.

If any one or more of these potential storage periods is cut off or greatly curtailed the existing reservoirs cannot store as much water as they have been able to store in the past. It becomes important, therefore, to consider whether these periods of potential storage are being invaded.

That these periods of potential storage are being invaded admits of no doubt. In the last few years a number of very large canals have been constructed. These canals are sometimes known by the significant name of "flood water canals." This very name implies

that these canals take the flood waters; that is, they expect to draw the water from the streams during the time of the spring run-off and the time of the summer floods when the streams carry more water than the older ditches can handle.

Of course, just in so far as these large new canals draw off the flood waters of the streams they come into direct conflict with the reservoirs. If these ditches are to be allowed to take the flood waters in preference to the rights of senior reservoirs, the time will come when it will not be possible for the reservoirs to store any water in spring or summer.

Moreover, these large, late ditches are also invading the winter storage season. The water supply under these late ditches being usually only a second class water right, the farmers under them have begun to irrigate their fields in the late fall and in the very early spring—in fact, at any and all times when the ground is not frozen during the five winter months. They do so on the theory that at least part of the water they put into the ground in this manner will be of value to the crops of the next season. This, however, constitutes a direct invasion of the winter storage season.

As an illustration of what all this may mean to municipalities, let us take the case of Colorado Springs. The municipal reservoirs of Colorado Springs are supplied by water from the tributaries of the Fountain, which in turn flows into the Arkansas. Every time that a new canal is built from the Fountain or from the Arkansas below its junction with the Fountain, the ability of Colorado Springs to fill its reservoirs is decreased if junior direct ditches are to be supplied in preference to senior reservoirs.

Not only is this question of importance to municipalities—it is also important to the great agricultural business of raising sugar beets. Sugar beets must be irrigated late in the summer when the streams are usually low. Beet raising, therefore, depends largely on reservoir water to "top off" the beets; so if storage is to be injuriously affected by the construction of "flood water canals" beet raising will suffer along with the cities and towns which depend on reservoir water.

The question under consideration, therefore, is not a question between agriculture and municipalities, but rather a question between reservoir owners and the "flood water canals."

This question involves some very serious considerations. Millions of dollars have been spent in the construction of great storage res-

ervoirs. Thousands of acres of farm lands have been brought to the high state of cultivation required for sugar beets in reliance upon these reservoirs. Municipalities ranging in size from small towns to great cities have grown up relying for their water supply upon these reservoirs. It is scarcely possible to measure the financial damage which will result if the reservoirs of the west are to be destroyed by the flood water canals.

Moreover, one of the cardinal principles of the western law of waters will be overturned. That principle is that the prosperity of the west demands an economic use of the waters of our streams. The use of water by means of the flood water canals is not economic. Economy in the use of water for irrigation demands that the water shall be applied to the crops at the time when the crops have the greatest need of the water. Water so applied has the maximum effect in producing crops. It is only possible, however, to so apply water when the landowner can control the supply of water. This control of the water supply is possible only in the case of very old ditches or in the case of reservoirs.

It is not possible for farmers under the flood water canals to apply the water when the crops most need it. They must apply the water when they can get it, entirely irrespective as to whether the time of application is best for the crops or not.

Studies have been made of some of the larger flood water canals which show that the amount of water diverted by these canals and spread upon the land is often very large. These same studies have also shown that the average crops produced under these flood water canals are much inferior to the crops produced under the old ditches or under an ample reservoir supply. In other words, water from a reservoir delivered at the times of the maximum need of the crops is much more productive than the same amount of water delivered by the flood water canals.

Permitting a junior direct user to take water ahead of a senior storage user would violate another fundamental principle of our western law of waters—the principle that an appropriator is entitled to the benefit of the river conditions as he found them.

Let us illustrate by taking the case of a group of people who desire to obtain a sure supply of water; perhaps for supplying a town; perhaps for raising sugar beets. These people, if they are properly advised, will employ engineers to make a study of the water possi-

bilities on the stream. The engineers will make a study of the stream. They will determine how much water the stream can be counted on to furnish. Let us say they find that the average amount of water which the stream will furnish is 50,000 acre feet.

The engineers will next determine how much water is taken by all existing water users. Let us suppose that they find that about 30,000 acre feet are needed to supply the existing ditches and reservoirs.

The engineers will then report that there is, on the average, about 20,000 acre feet of water in the stream subject to appropriation. In order to conserve this 20,000 acre feet and turn it into a steady, dependable supply, the engineers will probably advise the construction of a reservoir of sufficient size to collect the water in wet years and carry it over into dry years and thus to supply a regular flow of water.

Relying on this 20,000 acre feet of water, the town makes its growth or the beet fields are prepared.

Now let us assume that, after the reservoir has been in operation a number of years, a flood water canal is constructed on the same stream with a carrying capacity of 250 second feet. Such a canal will carry 500 acre feet a day, and, if it could only be filled twenty days in a year, it would take away 10,000 acre feet from the reservoir.

The town or beet raisers, relying on the reservoir, would find their water supply cut in half. This would probably mean financial ruin to the beet raiser and great damage to the town.

These evil results to the beet raiser or to the town would not be offset by any corresponding benefit to the landowners under the flood water canal; because a canal which could only get water twenty days out of each year could not provide adequate water to insure any satisfactory raising of crops.

These harmful results which would follow the allowing of water to a junior canal in preference to a senior reservoir are so startling that the courts, if they are made to realize the situation, ought to rule that water is to be distributed in accordance with priorities, whether the priorities are for direct use or for storage. The writer believes that the courts will so rule if they are fully advised.

The danger is, however, that some court will rule without full knowledge of how far reaching its decision will be and thus create a precedent which will be hard to overturn. To obviate the possibility of a hasty and ill-considered court decision ought to be the aim of

every reservoir owner, whether the reservoir is used by a municipality or for agriculture. The writer suggests that the Rocky Mountain Section of the American Water Works Association could not undertake a more important task than to take up this matter to the end that, whenever a case is brought in court involving this question, arrangements be made to see that the court is fully advised on all phases of the subject.

CEMENT LINING OF USED CAST IRON PIPE[1]

By J. R. Tanner[2]

In 1920 the West Palm Beach Water Company laid a 16-inch main across Lake Worth, just north of the Florida East Coast Railway Bridge to increase the water supply of the rapidly growing town of Palm Beach.

This main was constructed of standard bell and spigot cast iron pipe with a ball and socket, every fifth joint, to permit of its being caulked above water and then lowered to the bottom. No trench was dug and no base prepared for the pipe to rest upon, as it was supposed that the ball joints would provide sufficient flexibility to permit the pipe to bed itself on the more or less irregular lake bottom.

At the time of doing this work, the effect of the tides upon this particular part of the lake was almost negligible, because the inlet was too small to permit the passage of any considerable quantity of water, during the rise or fall of the tide. It is not definitely known how long this line remained intact, and operated without leakage, but in 1925, when the inlet was widened and deepened to many times its former capacity, the line began to develop frequent and serious leaks. These leaks were caused apparently, by the heavy tides removing the sand from the pipe and allowing settlement which either pulled the joints apart or caused cracked bells. Many repairs were made, both under water and by lifting the line and inserting sleeves and nipples to provide more length, to take care of the sag in the low places.

These breaks became more and more frequent, until the loss of water and the cost of maintenance amounted to such a figure as to demand the abandonment of the line in 1927. At that time the new 24-inch ball and socket line was laid in a deep trench just south of the bridge.

The old line at that time was in fair condition, as far as leaks were

[1] Presented before the Florida Section meeting, April 10, 1930.

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concerned, so it was closed and held in reserve as an emergency line, with enough pressure maintained to prevent the entrance of lake water.

Last fall, after two years of uninterrupted service through the 24-inch line, it was decided that the old 16-inch line should be salvaged and prepared for use in a proposed Palm Beach extension.

SALVAGING AN OLD SUBMERGED PIPE LINE

Following this decision, we started early in November, 1929, to assemble the equipment necessary for the removal of the line. This equipment consisted of one large barge with a swinging boom derrick, one small barge with a 20-foot "A" frame, the top of which extended a few feet beyond the bow, and our small diving barge with complete diving outfit.

Two chain blocks were attached to the top of the "A" frame on the small barge by means of heavy chains, 16 feet long. These blocks were hooked into other chains tied around the pipe at the west end, where it had already been detached and plugged. Both blocks were then taken up until the end of the pipe was high enough to permit the bow of the large barge to pass under it. The winch on the large barge was then brought into use, through the swinging boom, with a hitch around the end of the pipe, which pulled the barge forward under the pipe, as it was lifted by the two chain blocks. In this manner the entire equipment was moved along the line one joint at a time.

The separation of the standard bell and spigot joints was accomplished by the application of heat, from two Hauck kerosene burners, at the top of the joint until the lead was softened enough to permit the weight of the length of pipe to break the joint. This operation required about twelve to fifteen minutes for each joint.

When we arrived at the first ball and socket joint, it was apparent that some means would have to be devised to facilitate the separation of this type of joint, before we could approach our estimate of 120 feet per day. The quantity of lead in this type of joint is much greater than in the standard joint, and the largest diameter of the ball is well within the socket. These features together with its flexibility make this joint extremely difficult to separate. To accomplish this with the least loss of time, we built what we called a pipe puller. In effect, it was two 12-foot jacks built of 6-inch by

3-inch channels so connected that they rested on opposite sides of the pipe, with one end against the square face of the socket to be separated, and the other end connected with a heavy split ring just back of the bell. The power was applied through two $1\frac{1}{2}$-inch eye bolts hooked over ears on the split ring and passing through blocks across the ends of the channels. The nuts on these eye bolts were turned down with long wrenches as the heat was applied to the joint. This contrivance saved about forty-five minutes to one hour on each joint.

These statements of the time required to separate the two kinds of joints might lead you to expect much more rapid progress than we were able to make, but the lifting of the pipe, removing the barnacles and moving the heavy equipment against shifting tides, consumed the major portion of the time. Another loss of time was occasioned, in the early part of the job, by the separation of the pipe under water ahead of our tackle. This made it necessary to send the diver down, until we devised a long steel rod with a heavy hook hinged in one end. This hook could be dropped into the open end of the pipe with very little difficulty, and the chain blocks attached to the rod by means of a ring at the top end and another on the side of the rod, half way down.

This little contrivance was the greatest time saver on the job, since it took about two hours for the diver to get into his suit and make a new hitch on the pipe, whereas the hook did the same work in about ten minutes.

The matter of transporting the pipe from the barge to the yard seemed to us, at first, to be one of our most difficult problems, but when we were able to rent the large barge with the swinging boom, this problem practically solved itself, since we were close enough to the railroad bridge to swing the pipe from the deck of the barge to a push car on the track, thence to a truck at the end of the bridge.

As it quite frequently happens in handling these small unusual jobs, we were about half through before we really had all the lost motion eliminated, and the equipment working efficiently. From this time on, however, we were able to make up most of the lost time, and finally completed the job within a day or two of scheduled time, and at a cost of about 90 cents per foot. The cost of new pipe of this size is about \$3.00 per foot, so we could not have felt very badly even if our salvage cost had been as high as \$1.50 per foot.

CLEANING AND LINING SALVAGED PIPE

After the barnacles were removed from the outside of the pipe, it showed that the deterioration, due to its rather lengthy salt water bath, was almost negligible. The inside of the pipe was coated with a soft scaly substance, about $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in thickness and resembling flattened tubercles. This coating was easily removable by scrubbing.

We now find ourselves with something over 2,000 feet of 16-inch pipe in the yard, at a cost of about 90 cents per foot, but since we use nothing but cement lined pipe in the system, it is worthless, except as junk, unless we can successfully clean and line it at a reasonable cost.

While the pipe was being removed from the lake, we had built a makeshift machine on which to experiment with the cleaning and the lining process. This machine was built of scrap material gathered up about the plant and served a very useful purpose. From it, we developed a very efficient cleaning brush and learned that, with the proper equipment, we could clean and line pipe at a price that would not be prohibitive.

On first thought it would appear that the cleaning of the pipe should be a simple matter. This is more or less true, if you ignore the elements of time and cost, since there are many ways to thoroughly clean the inside of a pipe mounted on revolving trunnions. We first tried broken tile, crushed rock, scrap iron and heavy log chains. These materials were effective securing agents, but required entirely too much time since they do not lend themselves to efficient handling. We then tried a tool made up of four wooden backed steal brushes placed radially around the end of a 1-inch pipe about 15 feet long. This pipe has a cross at the other end, to provide handles for two men, and a hose connection on the open end of the cross. At the brush end it is drilled with fifteen $\frac{1}{8}$-inch holes on each side, so that two solid sheets of water are playing on the surface to remove the scale as quickly as the brush releases it.

These brushes, which were purchased from stock, were found to be very efficient unless the scale had gotten too dry and hard. In which event too much time was required. To obviate this difficulty, we made brushes of the same size, but instead of the fine round wire, we used the heavy gutter broom stock, such as is used on the large Austin street sweepers. Two of these improvised brushes were then used opposite two of the finer ones, to provide flexibility. This

combination produced the desired results, and we were able to clean pipe at the rate of twelve per hour, whereas our earlier attempts had required from fifteen to twenty minutes per length of pipe.

Our first attempts at cement lining were not attended with any marked degree of success. In fact, they were decidedly the opposite. As a result of these early efforts, we decided that there must be some little trick or tricks which so far had eluded us, so, rather than waste time trying to discover them for ourselves, I arranged for a trip to Birmingham to visit the plants where they were lining pipe in large quantities.

Mr. H. Y. Carson, of the Clow-National Company, is probably the foremost authority in the country on this class of work, and he was kind enough to devote a whole day to conducting me through their own plant, as well as that of the U. S. Cast Iron Pipe Company. At the National Plant, they were lining 20-inch pipe with a $\frac{1}{4}$-inch lining and at the U. S. Plant, 16-inch pipe with a $\frac{3}{16}$-inch lining. Our own immediate problem was with the latter, so I was able to get exactly the information I needed.

The machines in these two plants are almost identical, and consist of four cast iron trunnions 16-inches in diameter and $2\frac{1}{2}$-inches thick mounted on parallel shafts about 18 inches apart. These shafts are both driven by the same belt from a third shaft which is in turn belted to a variable speed motor. The idea of the large trunnions is to obviate the necessity of adjustments for different sizes of pipe. This machine will handle all sizes from 4- to 24-inch without change.

After observing the simplicity of these machines, it was not difficult to convince myself that we should scrap the experimental equipment at once and build a machine along the more substantial lines of those in use at the foundries. Pursuant to this decision, we built such a machine on a concrete foundation, but instead of using an electric motor for power, we substituted our Fordson tractor which has furnished power for almost everything from a suction dredge to unloading and hauling pipe.

In building this machine we were able to use a considerable amount of steel salvaged from hurricane wreckage, so that our total outlay for material was only about $200.00. As soon as the machine was completed we started in to successfully clean and line pipe. The tricks which had caused our earlier failures were so simple that we wondered why they had not been accidentally discovered. In our experiments we had tried various amounts of water and various

proportions of sand and cement, together with a range of speeds in the spinning of the pipe after spreading the cement. All of these experiments resulted in a thin wet surface which flowed freely to the bottom as soon as the pipe was stopped.

There are three rigid rules which must be adhered to in order to obtain anything like satisfactory results. The first is to trowel the mortar on as quickly as possible without raising the peripheral speed high enough to squeeze any water out of the mixture. The second is to smooth and settle the mortar against the walls as quickly as possible with a short snappy spin, by bringing the peripheral speed up to about 600 feet per minute as quickly as possible and then as soon as a shiny surface appears stop quickly by applying the brake. This final spinning is a matter of only a few seconds, and can be gauged very accurately by observation after the first few trials. The third rule is by far the most important, and the one most likely to be slighted by the average workman. It is the matter of curing. As soon as the pipe stops, the ends must be tightly covered with wet cloths of a close texture, so that all moisture will be retained in the pipe to prevent too rapid drying and the resultant cracking. These cloths should be kept wet for at least forty-eight hours and as much longer as practicable.

The materials used are Portland Cement, clean sharp sand and clean water. The cement and sand are both screened through 18 mesh screens, and mixed in proportions ranging from 25 to 50 percent sand. We find that $33\frac{1}{3}$ percent sand to $66\frac{2}{3}$ percent cement by volume, gives a mortar which is very easy to handle and leaves a very smooth surface. Under different weather conditions, as to temperature and humidity, it may be found advisable to vary these proportions.

A small concrete mixer is used to mix the mortar in batches large enough to line two 12-foot lengths of 16-inch pipe. The consistency of this mortar may be varied through a much greater range than one would expect, and still obtain satisfactory results, but the operators soon learn what amount of water to add for easy handling.

From the mixer the mortar is handled in coal buckets and placed in a trough made of $3\frac{1}{2}$-inch boiler tube with a $2\frac{1}{2}$-inch slot cut the length of the pipe to be lined. The ends are plugged and handles braised on so that the trough may be used as a trowel as well as a measure and a means of delivering the mortar to the pipe. In the earlier operations, this trough was filled by hand, but later we made

a small galvanized metal hopper which slides along the slot and levels off the mortar with very little effort and a considerable saving of time.

The trough in this case was designed to hold just the right amount of mortar to make a $\frac{3}{16}$-inch lining in a 12-foot length of 16-inch pipe. If the same trough is used for other sizes of pipe, the batch should be measured before placing it in the trough. Pipe from 4 to 12 inches in diameter should have an average minimum thickness of mortar of $\frac{1}{8}$-inch and from 14 to 24-inches this thickness should be increased to $\frac{3}{8}$-inch.

When the trough is filled it is inserted in the pipe at rest on the trunnions. The mortar is dumped and the pipe is revolved slowly while the trough is held against the side and moved back and forth endwise, until the mortar is spread evenly upon the surface. The pipe is then stopped and the trough withdrawn. If any spots are not covered, a long handled paddle is used to add a little mortar where needed. It is usually necessary to add a small amount at the ends, where some of the original mortar is worked out by the troweling operation. This can be done very quickly as it is not necessary to spread it smoothly. When the patching has been completed, the pipe is quickly brought up to high speed and as soon as the lining presents a shiny appearance it is stopped. This final spinning requires about six to ten seconds and the peripheral speed should be approximately 600 feet per minute. This speed, however, is not fixed, since it really is combined with the vibration of the pipe, to settle and smooth out the mortar. The proper speed and time are determined by observation rather than by instruments.

As soon as the pipe is lined the curing canvasses should be tightly tied over the ends, and allowed to remain there until the cement is finally set and as long after as practicable. These covers are kept wet by allowing a lawn sprinkler to play on the finished pipe for two or three days.

In some instances, we have had small cracks develop near the ends after the covers are removed and the cement is subject to the direct rays of the sun. These cracks are not serious because they will take up as soon as water is introduced in the completed line. There is a possibility, however, that there may be enough shrinkage in some cases, to cause a separation between the cement and the wall of the pipe, where there is still a trace of the bituminous coating which the pipe received at the foundry. This coating fills the pores

of the metal and the wire brush has a tendency to polish rather than to remove it. This condition might give rise to some trouble in handling, if it were necessary to line pipe and store it, in advance of construction, for any length of time, but we believe we can safely line all old pipe whether coated or not, if it is put into service as soon as the cement is completely set.

It is not our intention or desire to compete with the pipe foundries on the cement lining process, but rather to provide a means of using good material which otherwise would necessarily be sacrificed as junk.

Our costs are not low enough to permit the purchase of unlined pipe from the foundry with the hope of saving money by doing our own lining, because this would necessitate extra handling. We have, however, been able to clean and line 16-inch pipe for the same price charged by the foundry, namely about 19 cents per foot.

CORROSION AND CONSERVATION OF UNDERGROUND STRUCTURES[1]

By P. J. Richards[2]

Corrosion is the disintegration of metal due to chemical action.

Corrosion of underground metallic structures is caused by the action of chemicals in the soils, soil waters and other materials that are in contact with the buried metal; however, no appreciable corrosion can occur in the absence of moisture. A steel pipe may safely be buried in dry chemicals for an indefinite period, but if moisture is added, severe corrosion may result. Pure water will not corrode metal, but if a small amount of corrosive chemicals is dissolved in the water, it will become corrosive. We, therefore, have two major factors that must be considered in connection with corrosion: chemicals and moisture. In the presence of large amounts of chemicals that we know will attack metal when moist, moisture will be the controlling factor, but if the metal is constantly wet, the amount and character of the chemicals will control the severity of the corrosive action. There are also other factors that often tend to influence corrosive action to some degree, and in rare cases do exert a powerful influence. Among these may be mentioned temperature, physical characteristics of soil and differences in potential and stray currents.

Temperature will affect the rate of a chemical reaction and we will have more corrosion from a warm solution than from one that is cold. The physical characteristics of the soil will affect the rate of percolation of soil waters and will determine the character of contact between the metal and surrounding meterials. Heterogeneity of soils may lead to differences in potential within the soil itself and also between the soil and the buried metal. Differences in potential will probably accelerate corrosion to a degree proportionate to the current flow. Stray current electrolysis is an example of this type of factor.

If we will consider a pipe line as our underground structure, we will find that a practical application of these data can be made.

[1] Presented before the Rocky Mountain Section meeting, February 13, 1930.

[2] Consulting Chemist, Denver, Colo.

There is little difference in the rate of corrosion of iron and steel. Iron pipe is usually quite thick and as the pitting rate tends to decrease with the depth of the pits, a considerable service life is usually realized from iron, even in corrosive soils. However, the results of the Bureau of Standards soil corrosion studies show that the service lives of iron and steel pipe of the same thickness might be expected to be equal, if used under the same conditon.

If we intend to place a pipe in soil and wish to obtain an idea as to the length of service life that may be expected from it, we must know what chemicals are in the soil and also the amount and character of the soil waters. In most cases we can safely assume that most of the water that will be available will percolate through the soil from the surface down to the depth at which the bottom of the pipe will rest, but we must also consider that certain waters may be present that have traveled a considerable distance underground and, therefore, may have entirely different characteristics.

If a soil sample is taken by means of an auger from the surface down to the depth of the bottom of the ditch, we will obtain a cross section of soil through which surface waters will penetrate to reach the bottom of the pipe, and if we seal this sample immediately, we will be able to retain all of the natural occurring moisture. A chemical analysis of the soil and the waters or water extract will disclose the presence and amount of all chemicals that we know to be corrosive, non-corrosive, accelerators or inhibitors of corrosion. We will then be able to give the soil a chemical and physical rating in the scale of corrosiveness and this, when correlated with a study of the topography in the neighborhood of the test, with particular consideration to the drainage, exposure, and use of surface, will enable us to tell, with a reasonable degree of acurracy, whether the pipe will serve for a considerable period without any protection or whether the use of an expensive coating is justified.

It has been found that frequently the same characteristics obtain in a soil over considerable areas and close sampling need not be resorted to. However, if a decided change, either in the nature or amount of chemicals, is found in adjacent samples, it is necessary to take additional samples in order that the point of change may be located.

This method also has applications other than determining the relative corrosiveness of unknown soils. It has been used in the City of Denver to determine the dividing line between a decidedly corro-

sive and a comparatively non-corrosive section. It was found that on one side of the line considerable amounts of soluble chlorides and sulphates were in the soil, while on the other side very small amounts of these chemicals were present. The dividing line followed a contour line rather closely and could be accurately traced on a map of the gas distribution system. This line was then extended beyond the present distribution system in order that corrosive sections would be known when the system was extended. A corrosion survey was made of the City of Pueblo for the Pueblo Gas and Fuel Company, in order that the nature of the chemicals causing very severe corrosion in certain parts of the town could be determined and a means of protection suggested.

In conducting a survey of this nature it is well to keep in mind the fact that, regardless of the apparent dryness of the location, moisture is sure to reach the pipe at certain times. The amount and character of annual precipitation should be considered and also the probability that the trench will provide a drainage way for all excess moisture, both from rain fall and melting snow, and also for any ditches that may be near and above its bottom level. It is probable that the soil around the bottom of the pipe will always contain more moisture than will be found in the soil sample.

As we are sure that at least a certain amount of moisture will be available for chemical reaction, we must consider the chemicals in the soil and soil waters as most important factors to corrosion. In rating them as to their relative importance, it is well to remember that any chemical that will attack steel on the laboratory bench will attack steel in the ground. Strong alkalis are usually destructive, but the chlorides and sulphates seem to be the most harmful. Sulphides are dangerous because they may contact with the pipe and also because they are apt to be oxidized to sulphates at some time in the future. Calcium carbonate or limestone is not only non-corrosive, but seems to have an inhibiting action when corrosive chemicals also are present. All soil acids must be considered corrosive until some practical means is evolved for the separation of the various organic acids and the determinations of those that are most destructive.

Mountainous regions are usually alkaline and in arid regions the soils adjacent to them and extending for several hundred miles from the foot-hills are usually alkaline. As we get farther from the hills and into a region of increased rainfall, the alkalis are less strong, a considerable amount having been removed by leaching. When a

region of abundant vegetation is reached, we find that the soils have become acid for the most part, probably due to an abundance of organic acids generated in decayed plant life.

COMBATING SOIL CORROSION

It is of little use to determine when and where we may expect corrosion, unless we have some means of combating it successfully, or at least of modifying its destructive action. We are sure that no appreciable corrosion will occur to metal that is dry and, therefore, we may safely conclude that any material that is capable of excluding soil waters will present serious corrosion to underground structures. A film of any thickness that would be impermeable to all soil waters for an indefinite period would be an ideal coating, provided that it had the necessary properties to resist the stresses and abrasions of underground service. Until a material has been discovered that will provide such a film, we will be forced to depend upon a thick coat to protect the metal for any considerable time.

There can be no protection unless we have a continuous coat of the protecting material covering all parts of the metal. There is little doubt that most coating failures are due to misapplication, but it is also true that many failures are due to a poor choice of coatings. A certain coating giving satisfactory protection in one location may be totally unadapted to serve in another. The chemicals present in the soils must be considered.

Hot coatings, or coatings of materials that have to be heated for application, are often chosen without thought of the conditions under which they are to be used. The melting point is of the utmost importance. A material of high-melting point should be used in a hot climate in order that the coat will not run from the pipe before lowering, but that same material would be brittle and crack if applied to cold pipe and lowered and back-filled in cold weather. The use of a low melting point material in low temperatures will tend to assure you of a good coating on the buried pipe without the use of excessive amounts of "flux." High atmospheric temperatures, of course, demand a material of high melting point, which not only prevents sliding, but assures a coating that is hard enough to resist a considerable amount of abrasion and soil stress.

Wrapped coatings should be used where severe abrasion may be expected. The wrappings themselves usually have little or no resistance to soil waters, as they are seldom thoroughly impregnated with

the coating materials, but when properly applied they do protect the coating beneath from being removed by abrasion.

Paints containing vegetable oils should be avoided in alkaline soils, as the oils are apt to saponify. Concrete is subject to attack by certain chemicals found in soils. Thin coatings of any nature should not be used in extremely corrosive conditions. The addition of an inhibitor to any coating material may increase its efficiency by retarding corrosion after soil waters have penetrated to the metal.

The economics of protection must be considered in the following manner:

1. If metal is to be buried in a soil, will that soil destroy the metal in such a short time that some form of protection seems advisable?

2. Is it possible to obtain some form of protection that will prolong the service life of the structure?

3. Will the additional service life obtained assure an adequate return on the investment in protection?

It has been estimated that over half of the coating that has been applied to pipe lines in the past might have been saved if some knowledge of the corrosiveness of the locations had been obtained beforehand. We are probably safe in estimating that half of the remainder was either misapplied or underprotected, and a considerable amount not adapted to meet the existing conditions. Engineers and chemists are now devoting a great deal of time to the subject and are making rapid strides that will, undoubtedly, mean a saving of millions of dollars through preventing the use of unnecessary protection, but at the same time assuring adequate protection to service and investment.

SOME UNUSUAL CORROSION PROBLEMS[1]

By F. B. Porter[2]

Corrosion due to internally generated electric current and corrosion due to distilled water action at high temperatures are described in the following, and the evidence given on cases where this has occurred. These two unusual types of corrosion may not occur very often, but are important from the standpoint of economic loss and an understanding of them is an advantage in running down the cause of new cases of corrosion.

INTERNALLY GENERATED ELECTRIC CURRENT

In March, 1928, twenty tubes bagged in a 723 horse power, operating at about 2000 horse power, Babcock and Wilcox water tube boiler operating at 350 pounds pressure. Samples of the water in the boilers had been reddish in color for sometime. The bagging was found to be due to scale accumulation in the bends of these tubes. The analysis of this scale showed 69.5 percent of iron oxide, 4.2 percent aluminum oxide and 9.4 percent of calcium oxide. No scale was present in the boiler except in the bends of these tubes. As soon as the trouble developed, the treating and handling of the entire water system of the plant was carefully gone over. Regular daily tests had been made for some time on all the waters in the plant for alkalinity, causticity and hardness. The boiler feed water at this plant was mostly turbine condensate with the make-up supplied from a Scaife treating plant in which river water was treated. There was nothing about any of these waters that would account for the presence of the iron oxide in the boiler water. Tests were made daily on the boiler feed water for dissolved oxygen and none was found. The interior of the steam drums was pitted and blistered above the water line, both red and black blisters were found. The plates in one of the

[1] Presented before the Boiler Feed Water Studies Session, the St. Louis Convention, June 3, 1930.

[2] President, Southwestern Laboratories, Fort Worth, Tex.

turbines were found to be corroded. All of this indicated the action of gas; inasmuch as the tests showed the boiler feed water free from oxygen some other source must be found. The idea of gas being produced by electrolysis with the boiler acting as one electrode, and the overhead storage tank at a lower temperature as the other, with the boiler feed water as the electrolyte, was suggested. A millivoltmeter showed a difference of potential. Tests were made to determine whether the electric current was due to leakage from excitors or telephone system. This was found not to be the case.

The steam drum of a boiler was connected by means of a heavy copper insulated cable to a piece of zinc and the zinc suspended in the water of the overhead storage tank. The difference in potential in this circuit was more than 50 millivolts. The zinc plate was soon found to be corroded. Copper bus bars were then fastened to the steam drums on all the boilers and a connecting line installed from these drums to the sheet zinc suspended in the water in the overhead tank. Readings taken with a milliammeter at regular intervals showed 0 to 300. As soon as the zinc plate was anchored the milliammeter reading remained constantly above 400 which was the capacity of the instrument. This showed that the zinc touching the side of the tank had been making a short circuit when the low readings above mentioned were taken. It was found that it was necessary to renew the zinc plate once a month and to clean it once a week. This installation removed most of the red color from the water in the boiler, but, if anything happened to the circuit or to the zinc, the water in the boiler immediately became a deeper red. No additional accumulation of red scale in the tubes and no further pitting in the drums were observed. Evaporators were installed to supply the boiler feed make-up in the fall of 1928. The resulting change in the boiler feed water due to changing the make-up from soda ash and lime treated water to distilled water immediately dropped the readings on the milliammeter below 120. At times, with practically pure distilled water, the reading was zero.

A case of bad corrosion in oil well piping has been explained on the same general idea as the above except that different kinds of steel rather than difference in temperature was believed to have been the chief cause of the flow of current. By adopting preventive measures in line with this explanation the corrosion has been stopped. The electrolyte in this case was an oil field brine. It seems quite logical to conclude that currents of sufficient size to cause destructive corro-

sion are sometimes generated when steel is in contact with an electrolyte and when there are differences in temperature and in composition. The overhead storage tank, of course, was much cooler than the drum of the boiler and the composition of the steel probably very different. In the case of the oil well casing, the steel was known to be of very different composition.

DISTILLED WATER CORROSION

The other type of corrosion might be designated as distilled water corrosion. In the case of another power plant, even though the raw water was bad for boiler use, the turbine condenser leakage and evaporator priming was cut down to the point where water in the boiler day after day was free from scale producing constituents, and was low in alkalinity, seldom getting above five grains. This resulted in pitting and corrosion in the drums below the water line. No oxygen was present in the boiler feed water at this plant. The plant had been run for considerable time with fifteen grains or more alkalinity in the boiler without showing any tendency to pit. After the pitting was observed the alkalinity was increased to fifteen grains or more and the pitting stopped. We feel that a hydrogen ion reading such as is recommended for corrosion prevention in ice brine work is not applicable or satisfactory for boiler water because of much higher temperatures. At the plant where this distilled water pitting occurred, the raw water was high in calcium sulphate. After treating with zeolite this water was used in the service piping around the plant. Some of this piping was eaten out completely within a year. Two and one-half grains per gallon of caustic soda is being added to this zeolite treated water to keep the pH reading above 9.0. We have reason to believe that this is preventing this very unusual corrosion.

At another Texas plant, even though the alkalinity was maintained in the boilers themselves, the high pressure economizers were corroded. The boiler feed water which was composed of turbine condensate and distilled boiler feed make-up was circulated through the high pressure economizers before mixing with the water in the boiler. By means of a pump, water from the boilers was mixed with this boiler feed water before entering the high pressure economizers and the corrosion in the economizers stopped by this means. Enough causticity from the boilers was added to keep the pH reading in the boiler feed water in these economizers above 8.5. Since evaporators are in operation at the first plant mentioned in this paper, a small

amount of red oxide is present in the boiler water which we have every reason to believe comes from the effect of the distilled water on the high pressure economizers. It is planned to install the necessary lines and a pump to mix boiler water with the boiler feed water before it enters the economizers.

MECHANICAL ACCOUNTING FOR WATER UTILITIES[1]

By P. H. Hutchinson[2]

The purpose of this paper is to outline the application of machine methods to the various classes of water utility accounting with a rough idea as to their value and the savings to be obtained by the adoption of such methods. The various classes of the accounting work under discussion are distributed somewhat as follows:

	percent
Customers Accounting	50
Payroll Accounting	15
Materials and Supplies Accounting	15
Accounts Payable	8
General Records	8
Reporting Work	4

When the assistance of machines was considered it was first applied on the largest group of work, namely; Customer's Accounting. The adoption of mechanical accounting in this department has been very popular and is today almost universal. It is considered that it pays to use large machines whenever the number of meters to be handled exceeds 3800. Machines with fewer automatic features are available at very reasonable prices where a smaller number of meters is in service.

Many of the large utility groups and also many of the individual companies have gone further than to simply introduce machines on this work by divorcing themselves from ledgers in favor of what is known as the "bill stub plan" or "Baltimore plan of Bookless Bookkeeping. The plan has been explained in several of the Association's group meetings and in waterworks literature.

CUSTOMERS ACCOUNTING

Let us consider what the attraction has been that has drawn so many to use machines on customers accounting. The answer is the

[1] Presented before the St. Louis Convention, June 5, 1930.

[2] Public Service Division, Burroughs Adding Machine Company, New York, N. Y.

old slogan of improved production at decreased costs. The improvements are:

First: Neatness—Better looking bills and more legible internal records.

Second: Accuracy—The bill, cashiers coupon and ledger record cannot differ; the consumption is proved to be the difference between the readings; the extension of the quantity used by the rate applicable is guaranteed and the Revenue is certain because it is the amout of each bill added as it is printed.

Third: Control—There is a stipulated total of what bills have been sent out and any defalcation can be easily detected because cash received plus uncollected accounts must check to the amount of bills printed.

Fourth: Speed—The machines used can prepare the bills, coupons, ledgers and revenue statistics at a production of from 700 complicated accounts to 3000 simple single line accounts per machine per day.

While all these very desirable results are being obtained, money is being saved as the accounting cost can be reduced on an average of about twenty-five cents per account per year. On that basis, on 10,000 accounts about $2,500.00 can be saved each year. When a main extension is considered the popular ratio is that the investment should not exceed five and a half times the return. That means at a 50 percent operating ratio to earn $5,000.00 gross revenue or $2,500.00 net, the justified investment would amount to $27,500.00. To earn the same net return with a Customer's Accounting installation, using the most up-to-date equipment, the investment would not exceed $6,000.00 including the billing machine, automatic addressing equipment with plates and plate cabinets, binders for ledger stubs, fireproof filing equipment and automatic stamping and sealing equipment.

Mr. John L. Conover of the Public Service of New Jersey, who have about 1,200,000 meters, states in a paper on Customer's Accounting that his organization realized a saving in labor alone of $300,000.00 per year by introducing a machine operated Stub Plan. A private water company with 18,000 customers saved about $12,000.00 per year by introducing the same system and at the same time changing over from monthly to quarterly staggered billing.

Many water departments and companies have installed machine methods on their customers accounting work, obtaining additional

results and at the same time realizing a saving sufficient to cover their equipment investment in from one to two years.

Utilities that had obtained such desirable results on their largest group of work naturally turned their attention to the other half of their accounting problem, applied the same principles and obtained the same results.

PAYROLL ACCOUNTING

Let us take Payroll accounting as the class of work next in importance. To get the best results from personnel, the employees must have 100 percent confidence in the company and men they work for. If an employee does not receive his or her paycheck regularly and without waiting, that confidence, which is so important and valuable, is undermined and often ruined. A company or department of any size by using machine methods on Payroll work can have available before the end of the following day the earnings of each employee, for the period to date, and the accumulated labor expense charge to each account, for the month to date. When it comes to pay day there is no tedious work to be done, no errors to be made in the rush and no overtime is necessary to get the paychecks to the staff on time.

The original data from the timekeeper go direct to a machine operator who extends the hours worked by each man on each account at the man's rate. The machine product being in units is sorted and posted two ways—first, to the man's accumulated earnings to date and second, to the accumulated expense charges to date by accounts. When it comes to pay day, the work is very simple and straightforward. Machines are in use which prepare at one time at the rate of up to several hundred per hour all the necessary records:

1. The employees statement of wages.
2. The pay check.
3. The employees income tax and earnings record.
4. The payroll list.
5. The check register sheet for reconcilition with the payroll bank account.

These machines accumulate the gross pay, make the necessary deductions, ascertain the net pay and print and protect it on the check together with the date and consecutive check number. At the same operation the gross pay, net pay, and deductions for all employees are added and totaled. If payrolls are paid by cash the same routine

can be followed, except that a pay envelope is printed instead of a paycheck.

MATERIALS AND SUPPLIES

Materials and Supplies Accounting is handled in much the same way as the payroll. All receiving reports, issues and returns come to the office in skeleton form showing only the class of stock and quantity and are priced and extended by the machines. Totals are added while this extending is done to get the day's cost figures and to obtain the figures to control the postings to the stock records and distribution cards. All postings to the stock records and distribution accounts are made by machine and all work is balanced as it is performed. Each month, if desired, an inventory list is prepared and the whole or any part of the physical stock can be verified. Materials accounting is one that has always presented a ticklish problem from the point of control and it is often difficult to ascertain whether shortages are due to defalcation, carelessness in not preparing issue tickets or poor accounting. The adoption of machine methods on this class of work has made large strides in the right direction by making the accounting fool-proof and thereby pinning the responsibility for any shortage on the storekeeper, who, in turn, is going to be more particular about getting a signature for everything that goes out of his store.

MISCELLANEOUS RECORDS

Up to this point we have considered methods of handling 80 percent of the accounting problem. The remaining 20 percent covers accounts payable, general records and reporting work. The size and type of the company or department would decide the machine requirements on these activities. Where the quantity to be handled is large enough, special machines can be used, but the work can be just as easily done on the Payroll or Materials machines by the addition of special features to handle any additional operations.

In the small utilities where the volume of work is not large all accounting can usually be handled by two machines or even in some cases by one.

Many municipal departments use their customer's accounting machines to handle water, tax and assessment billing.

Some of you will contend that, while it would pay large properties to adopt machine methods on their general accounting, it would not

work out so well on a smaller unit. The same question arose in the first stages of customers accounting machine methods and yet it has proved worth while to both large and small utilities.

Accounting machines today are sufficiently flexible to permit of many classes of work being performed on one machine and it rests with each person to ascertain whether a thing can be done before they decide it cannot.

One must not conclude from this paper that machine methods are the only thing and that anyone who does not use machines for everything is behind the times. I am very much against the individual who walks into an office and immediately decides that everything is wrong and should be changed to his system. The reason possibly is that that individual knows only one system, and, while the system may have worked well somewhere else, it may not fit at all well. In working out a system one must look to the old-timers in an organization who know the business. What was done before was done to give them the information they wanted and there must have been a very good reason for adopting the method already in force or it would not be there. The axiom is do not change a system unless the only way to improve it is to change it. If it is not working properly find out why.

Mr. W. H. Leffingwell in one of his books suggests that in making an examination of a system in force the following questions should be answered.

1. Is the work now being done satisfactorily? if not, why?
2. Is it due to some defect in the workers, or is it inherent in the operation?
3. In what particular form is it unsatisfactory?
4. Do the workers object to the work? If so, what is the objection? Is it a valid one?
5. What does the factor of time mean in this operation? Is it important to reduce the overall time?
6. What does it cost to do the work?
7. Can it be done more cheaply by hand by improving the operation?
8. What advantage is to be gained by having the work done by machine? Will it save labor, time or drudgery?

Having thus analysed the need for a machine and having decided that a machine is necessary set about finding the proper machine for the job.

The foremost machine companies catering to the needs of public utility organizations have men specialized in every branch of public

utility accounting and they will willingly make a survey of your work and submit their recommendations and proposals. Having received the proposals, probably the best way to decide as to the merits of each is to ascertain from other utilities using similar equipment what their experience has been. If these users are willing to supply information on the following lines you will have something very definite to work on:

1. Production obtained
2. Errors, as percent of items produced
3. Speed and facility of paper handling
4. Amount of investment
5. Operating cost first year
6. Operating cost following year

Two points of importance often overlooked when considering the purchase of equipment are service in the case of breakdowns, and the question of obtaining efficient operators.

So much for what machines will do in connection with water utility accounting and how to select them. In conclusion, let me enumerate a few *Don'ts* relative to machine methods:

1. Don't expect any system to work without proper supervision or planning.
2. Don't expect the machine to go around and collect the work. It can't do it. There must be a regular feed of work to the machine to get results.
3. Don't expect a machine to perform its alloted function under poor operation or improper handling. See that the operator really knows how to operate the machine.
4. Don't forget to have your machine serviced regularly.
5. Don't put a machine to work until the work is ready for the machine.

DISCUSSION

L. M. Anderson:[3] The use of mechanical appliances in accounting and office work has passed the point of argument as to efficiency and necessity.

The use of typewriters, adding, addressing, tabulating and postage machines, etc., are a necessity in this day and an office would be

[3] Controller, Department of Water and Power, Los Angeles, Calif.

poorly equipped if it did not have one or more of these machines at least.

Since the introduction of the typewriter the number of mechanical appliances has increased rapidly.

The only argument that has to be made in this day is the one to overcome the prejudice of those who are afraid to make a change from one type of appliance to another in their line of work. Due care should be exercised in the selection of the proper equipment for the work to be performed.

There are a number of elements to be considered in making the selection of equipment such as original cost, adaptability, reliability, speed and cost of operation and maintenance.

The kind and volume of business may be a deciding factor in the selection of equipment. The question of how much statistical information is required, may have a bearing on the choice of an appliance.

The Department of Water and Power of the City of Los Angeles has pioneered in the use of mechanical appliances in consumers accounting.

The first innovation was writing in the name, house number and amount with a typewriter on a form of bill printed and arranged in street order.

The next step was the use of a paper stencil addressing machine on which the name, address and amount of bill was cut. This worked very well for flat rate bills and was used until meters were installed when it was found that a more flexible appliance was required.

We then purchased an addressograph for printing the addresses and billing machines which were used for both billing and bookkeeping. Later the billing and bookkeeping machines were discarded and a radical change made in methods, by the installation of key punch card machines and tabulators. We find this last arrangement very satisfactory, as it permits of proof of accuracy in billing and, in addition, almost unlimited statistical information can be obtained with little, if any, additional cost.

Following is an outline of operations from the time a bill is made from the meter reading book until the account has been closed for the month. Bills are rendered monthly.

The City is divided into twenty-three districts called serials for convenience in meter reading and collecting. One of these districts or serials is read each working day starting with the first day of the month.

The meter readers make extension of the consumption, noting all unusual consumptions, extraordinary conditions preventing the reading of a meter, noting the reason and place a clip on the reading sheet.

The reading books are then delivered to the office of the meter reading section where all clip sheets are gone over and orders made for re-reads, hold, tests, etc.

During the day while the meters are being read in the field the ledger cards and post card bills are addressographed and bill numbers automatically key punched on ledger cards. The ledger cards are sent to the tabulating section where the book number and dates of readings are gang-punched. The reading books are then delivered to the billing section and all accumulated orders of various kinds are entered in the meter books. The books are then gone through page by page by a clerk who scrutinizes reading dates, notations made by readers of broken dates, holds, combines, charges actual, etc. and the information noted on corresponding consumer's bill. The meter books are then sent to the key punch section where ledger cards are punched showing kind and class of service, present and previous readings and consumption. All irregular bills are punched in entirety and coded as irregular.

A proof of the correctness of the key punching is made by tabulating the ledger cards for each reading book on a standard non-printing tabulator accumulating totals of present readings, previous readings and consumption. An addition of the previous reads and consumption figures should result in the total of the present readings. This operation proves not only the correctness of the key punching, but also the correctness of the extensions made by the meter readers.

The ledger cards, after proof of key punching, are sent to the tabulating section where they are sorted to *similar groups* of consumption and class and the amount gang-punched. A proof-run is made showing the number of bills of like consumption and like classification with the total amount of money billed in each group. These groups are checked for correctness of rate application. The cards are then serted to book and bill number order and a tabulation is made by books showing the total water chargers.

All accounts from the previous month which show either a debit or credit balance are recut on a yellow tabulating card for debits and a red card for credits and are sorted in with the current month's tabulating cards. The ledger cards are then taken to the bill printer and the bills printed.

The punched ledger cards are then sent to the consumers bookkeeping section and filed in the order of the book number and the bills sent to the mailing section.

All payments made at the office are put through a cash register accumulating a total.

Periodically during the day, cash stubs are picked up at the cash registers and sorted to book number. At the end of the day a reading is made of the cash register accumulations and turned in to the cashier an amount of money agreeing with the cash register total.

The cash posting force comes on duty at 5:30 p.m. The posting operation consists merely in matching the paid stub to the ledger card which is removed from the file. The total of these cards must balance with the cash register totals. The cards are then filed in the paid file in book and bill number order.

Three days prior to the next month's billing of the serial, a run is made of all open items in the ledger and is balanced with the control.

We are using the same equipment to a great extent in the general accounting. Where it formerly required several weeks to get a trial balance after the month's business was closed, it now only requires three days.

In this brief discussion I have given more time to the use of mechanical equipment in connection with consumer's accounts than to its use in general accounting, as there seems to be more interest in that feature of operation. We find, however, very practical use can be made of such equipment in general accounting, warehouse records and payrolls.

Altogether the results obtained in using machine methods have been very satisfactory.

OILER FEED WATER TREATMENT IN GREAT BRITAIN[1]

By A. W. Chapman[2]

Within the limits of a short paper it is not possible to review the great variety of processes employed in Great Britain for the treatment of boiler feed water. Conditions at different plants are so diverse that examples of almost every kind of treatment are to be found, and attention will therefore be confined to a few of those aspects of the subject which have come under the writer's notice.

LIME-SODA AND ZEOLITE SOFTENING

For many plants the make up water is softened by the lime-soda or by the zeolite process or by both combined. The former process is employed very widely and the bulk of the external treatment is probably done this way. Trouble sometimes arises when the softening plant is overworked and insufficient time is thus allowed for complete precipitation and settlement of the precipitated material, since neglect of this precaution leads to the formation of a deposit, consisting largely of calcium carbonate, in the feed lines and other parts in contact with the softened water. The provision of an ample supply of nuclei upon which deposition can take place will, however, hasten the completion of the precipitation, and an interesting application of this fact has been made in a large lime-soda plant recently supplied as part of a complete lime-soda-zeolite installation for an electrical power station.[3]

The mixture of water and reagents from the proportioning gear passes down a pipe to the bottom of the settling tank, and, owing to the design of the top of the downtake, carries with it a certain amount of entrapped air. On reaching the bottom the air rises and escapes through a device fitted in the tank, causing as it rises a vigor-

[1] Presented before the Boiler Feed Water Studies Session, the St. Louis Convention, June 3, 1930.

[2] The University of Sheffield, Sheffield, England.

[3] The Engineer, 1929, 148: 486.

ous agitation of the water with the sludge deposited at the bottom so that the solution is abundantly nucleated. The design of the apparatus is such, however, that the agitation is confined to the water in the lower part of the tank and settling readily takes place above.

Some installations provide successive treatment with lime and soda and with zeolite, care being taken that the water is under-treated in the first stage. With very rapidly variable water it is not always easy to ensure the observance of this condition and the author's attention was recently drawn to a case where fluctuations in the quality of the water were causing a good deal of trouble. Although the changes in hardness were being adequately dealt with by the zeolite plant this involved at times the introduction of an undesirable amount of sodium carbonate into the boiler water, and at others the danger of passing an alkaline water through the zeolite bed. Until an automatic apparatus is available capable of adjusting the proportions of reagent and water to the changes in the composition of the water, the difficulties attending the adequate treatment of very variable supplies would appear to be insuperable.[4]

In some other cases pretreatment has taken the simpler form of removal of the bulk of the temporary hardness with lime, or, when the ratio of temporary and permanent hardness has been suitable, of the addition of caustic soda sufficient to deal with most of the temporary and part of the permanent hardness before passing the water on to the zeolite softener.

CAUSTIC EMBRITTLEMENT

It is probable that caustic embrittlement in boilers is less common in this country than in America, but the danger from this source has been realized and precautions are taken against it both by avoidance or removal of excess of alkali in the feed water and by adjustment of the alkali sulphate ratio. Treatment with calcium chloride to remove free carbonate or with sulphuric acid or acid sulphates is in use in some cases.

MOORLAND WATERS

Part of the industrial area of this country derives its main water supplies from the surface of moorland. Such water is usually soft,

[4] Apparatus for this purpose has recently been described, see British Patent 282,487 and Chemical Abstracts, 1928, pages 3555, 3718.

but, as it is occasionally slightly acid and is nearly always corrosive, it is rarely suitable for boiler feed purposes in the untreated condition.

It has recently been suggested that the superiority of softened over naturally soft water as regards corrosion lies in the softened water frequently being supersaturated with calcium carbonate and so producing a thin protective layer on the exposed metal surfaces. Although this view may be true to some extent the softened water derives a great advantage from the trace of free alkali which it contains, and the naturally soft moorland supply often needs only the addition of a very small quantity of alkali to prevent corrosion of the boiler. As an illustration the case of a pair of Cornish boilers fed with untreated water of moorland origin may be quoted. Extensive corrosion of these boilers was taking place, the plates being covered with a scale consisting largely of rust. Caustic soda was then added to the feed water so as to maintain a concentration of 3 to 4 grains per gallon of free caustic soda in the boiler water and the trouble at once came to an end, a very thin scale of calcium carbonate and calcium sulphate only being formed, without any precautions being taken against the presence of oxygen in the feed water. In the light of experience of this kind it seems probable that where the feed enters a large mass of water in the boiler the air is often boiled out before much of it comes into contact with the metal. In such cases the presence of oxygen is relatively harmless compared with the effect it exercises in locomotive or water tube boilers where the oxygenated water may come into intimate contact with the metal before the gas has a chance to escape.

HIGH PRESSURE OPERATION

In Great Britain the installation of very high pressure boilers is taking place later than in the United States. The majority of power station plants are working at pressures not exceeding 400 pounds per square inch and eighteen months ago the highest pressure in actual commercial operation is stated to have been not more than 600 pounds.[5] Since then, however, several plants for high pressures have been erected, one designed to work above 1000 pounds per square inch is nearly ready for operation, and others are being built or are in contemplation. In all units for pressures above 800 pounds per square inch the details of which have come to the writer's notice,

[5] Applied Chemistry Reports, 1928, 13: 17.

provision is made for make up with distilled water, and in at least one of these the boiler water itself will be conditioned with sodium phosphate in order to avoid trouble due to condenser leakages.

Full details of the conditioning of the boiler water in a large number of moderately high pressure plants are not available, but there is reason to suppose that sodium phosphate is frequently employed as a final internal treatment, and in a few cases the composition of the boiler water appears to be controlled along the lines developed in America by the masterly researches of R. E. Hall and his collaborators.[6]

[6] Bulletin 24, Carnegie Institute of Technology, Pittsburgh; and other publications.

SAND-SPUN PIPE[1]

By W. A. Brown[2]

The world's use of iron began even before civilization developed. At first the rich and available ores were de-carbonized by mixing with charcoal in a comparatively small hearth—a little better than a blacksmith's forge—the technical name for which was "Catalan Forges." In this way the iron in the early centuries, back probably 5000 years, was secured.

It was the fourth century of the present era when some progress was made as to more effective ways of handling materials, such as developing mechanical methods for securing an air supply by bellows.

Cast iron as known at the present time was not developed until about 500 years ago, when what is practically a blast furnace was developed, often making but a comparatively few tons per day.

This small blast furnace has been developed until at the present time the largest furnaces turn out 1000 tons a day.

It may be interesting to add that the developments of iron production were carried on in the middle of Africa as well as in Asia.

HISTORY OF CAST IRON PIPE

The first cast iron water pipes were laid near Paris in 1664. These varied in size from 13 to 20 inches, and the pipe lines varied in length from 1 to 2 miles. The pipe sections were short, being a little over 3 feet in length, and were bolted together by flanges on the ends. As far as is known they are still in existence. Records show these pipes were cast in a horizontal position.

About 1785, Thomas Simpson, Water Engineer of the Chelsea Water Company, London, designed the first bell and spigot pipe. Some of these pipe lines which were laid in London have been in continuous service for 135 years. These pipes were made in longer lengths and cast in a vertical position, which is one of the methods of today.

[1] Presented before the St. Louis Convention, June 6, 1930.
[2] Engineer, R. D. Wood and Company, Philadelphia, Pa.

Between Simpson and the foundrymen, the cast iron pipe industry was revolutionized, and the problem of sanitation and water supply was solved in every community.

The first cast iron water pipe, laid in the United States came from Engand, early in the nineteenth century. Only recently some of these pipes were dug up in Philadelphia, and found to be in excellent condition. They range in diameter from 4 to 20 inches, in 9-foot lengths, and are of the familiar bell and spigot type.

Philadelphia was among the first of American cities to specify cast iron water mains, and that probably accounts for the fact that the first pipe shops were established across the Delaware River, in New Jersey, close to the natural deposits of moulding sands.

In 1803, the Wood family commenced making cast iron pipe at their shop in Millville, N. J. In 1854 a new shop was built at Florence, N. J. located on the Delaware River just above Philadelphia. The firm is known as R. D. Wood and Company, and for many years has been managed by Walter Wood, oldest living manufacturer of cast iron pipe.

The principle involved in casting metal by the centrifugal process is not new. The first instance known of using centrifugal force to cast metal dates back to 1809, when an Englishman obtained patent rights on this method. Since that time, both in United States and abroad, much experimenting has been done to develop a method for producing successfully cast iron pipe centrifugally.

During the years 1924 and 1925, R. D. Wood and Company erected and equipped a modern shop for the production of cast iron water and gas pipe by the centrifugal process, in sand lined iron flasks. This shop has a potential capacity of over 300 tons per day.

With the addition of this shop the entire plant covers 67 acres.

SAND CAST PIPE

Molds in this method are rammed, dried and cast vertically in pits contained in the shop. The old circular pits and cumbersome hydraulic cranes, which served them, have been replaced with rectangular pits, running the full length of the shop, and overhead electric cranes.

Flasks are usually made to make two pipes, depending upon the size. They are split on the vertical axis and hinged on one side, the other side being held together with clamps.

The molds are made and cast "heads down," which insures clean

metal in the bell and throughout the body, any impurities rising to the top being taken care of by means of a "riser" above the bead, which is cut off in a lathe forming the bead.

The flask is placed on ramming station and the body pattern placed inside. The sand is rammed around the pattern forming the outside of the pipe.

After the mold is rammed, the bell core is placed in the chill, and mold lowered over it. It is then placed on the drying oven. At

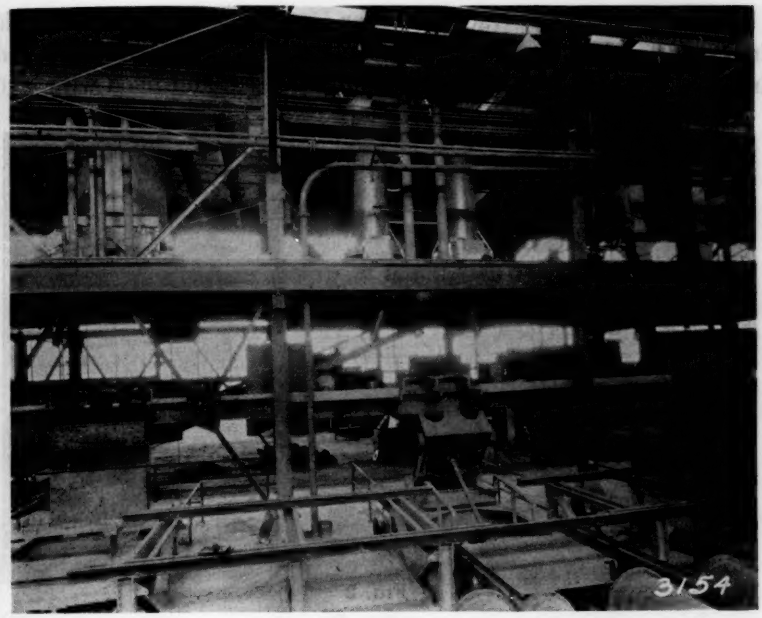

FIG. 1

the same time the core, which forms the inside of the pipe, is made and dried after its coating has been finished in the strike.

When they are both dried, the mold is placed in the pit and the core lowered into it. The core must then be "centered up" and a gate made, into which the iron is poured.

Shortly after pouring, the spindle is withdrawn and the pipe allowed to cool off. The flask is then placed on the discharge skid, the clamps removed, thus opening the flask and discharging the pipe and sand. The sand is then reconditioned with new sand and clay wash, and is used over again.

The pipes are then examined, weighed, hydrostatically tested and finally inspected and placed in the storage yard.

In our foundry a riser or shrink-head is cast on the pipe, to take care of impurities in the iron, bringing them to the top of the pipe. This shrink-head or riser is later cut off and the bead of the pipe formed. This adds to the cost of manufacture. The results obtained, however, make this additional cost well worth while.

"SAND-SPUN" CENTRIFUGAL PIPE

"Sand-Spun" is the trade name for a centrifugally cast pipe made in a sand lined mold. The mold of a "Sand-Spun" pipe is contained in a cylindrical cast iron flask, suitably vented, and lined with high

FIG. 2

grade molding sand. The sand is evenly rammed in the flask at the ramming stations.

A picture of the ramming stations is shown in figure 1. Molds are rammed, one, two or three at one time, according to the size of the pipe being made.

The molds are rammed in a device which centers the body pattern with respect to the roller surfaces on the flask. Oil sand and bead rings are inserted in the mold, after it has been rammed, to form the end of the bead.

After the mold is formed, it is faced with a refractory blacking, and by means of a tilting table lowered to the horizontal position. (See figure 2.)

As a green sand mold is used in the "Sand-Spun" method, the mold passes drying torches at intervals which take out the excess dampness contained in the wet facing.

The mold is then placed by overhead crane on the "Twister" skids. The oil sand bell core is then set in and the completed mold rolled into the "Twister" or centrifugal casting machine.

A view of the rear end of the "Twister," showing the pouring spouts and ladle, is shown in figure 3.

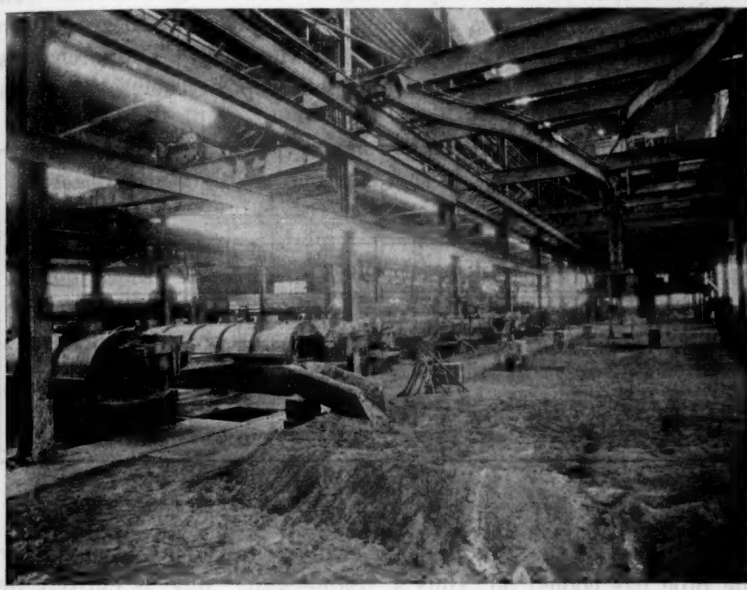

FIG. 3

Iron from the cupola is then conveyed by means of a crane to the pouring ladles of the "Twister."

The mold is slowly revolved by direct connection with an electric motor. A charge of iron required to make the pipe is poured into the mold from the measuring ladle into the spout, which projects the molten metal into the mold and distributes it along its entire length. When the metal is completely discharged, the speed of the mold is immediately and rapidly increased so that the centrifugal force distributes the metal upon the sand wall of the mold, forming the pipe in its true shape and holding it there until the metal sets. This is schematically shown in figure 4.

Due to this method of manufacture, there is no chilling of the iron, so that any internal casting strains developed in the pipe are taken care of. A casting made by the "Sand-Spun" method is of the same structural metal as a casting made by the Sand Cast method, which has long been in existence, except that a casting made by the "Sand-Spun" centrifugal method is finer grained, denser in structure and homogeneous throughout.

Centrifugal action in a sand lined mold permits the iron to congeal slowly and clear itself entirely of all gases and foreign material. The centrifugal action causes the moisture in the sand to go outward through the sand and the vent holes in the flask. The foreign materials being lighter than the iron itself, deposit themselves on the

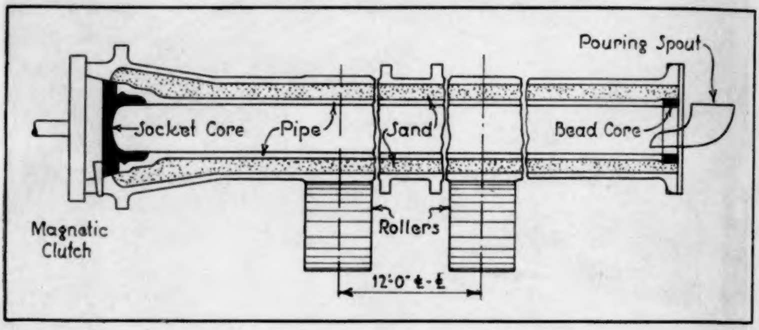

FIG. 4

inner surface of the pipe and are easily removed by cleaning after the pipe has cooled off; thus a "Sand-Spun" pipe is entirely free from all inclusions.

After the pipe has been cast, the flask is removed from the "Twister," placed on the cooling skids and passes to the stripping stations. These skids are long enough to allow the pipe to gradually cool until no trace of heat remains. The pipes are then removed from the flask by the stripping machine and placed on the cleaning skids.

The sand from the flask drops into bins located beneath the stripping machines. It is then carefully reconditioned by means of the sand mixing machine, and the addition of proportionate amounts of clay wash and new sand. From the sand mixing machine it passes, by means of conveyors, to the overhead bins located over the ramming stations.

A sand laboratory, in charge of a sand expert, is maintained in which samples of sand from each "batch" are tested for permeability, moisture, fineness and bond.

The pipes are then examined and given first inspection. After cleaning they are again inspected. They then pass through the heating oven, placed in the coating tank and drained.

They are then weighed and hydrostatically tested to a pressure of 500 pounds per square inch, given final inspection and then pass on to the storage skids in the yard to await shipment.

If cement lined pipes are required, they pass to the cement lining shed where a mixture of cement, sand and water is applied to the inside of the pipe centrifugally.

"Sand-Spun" pipe is made in 16 foot and longer lengths. Being this length instead of the pit cast length of 12 feet results in saving joints and laying time, thus reducing the cost of laying.

Very shortly "Sand-Spun" pipe may be obtained up to 48-inch in diameter and 20 feet in length.

"Sand-Spun" pipe being intrinsically stronger in every respect than pit cast pipe, permits a reduction of body thickness and makes "Sand-Spun" pipe (16 feet long), of the same weight as a sand cast pipe (12 feet long), good for greater working pressure and withstands greater test pressure in the course of manufacture.

Some of the advantages of "Sand-Spun" pipe over pit cast pipes are:

1. Increased strength of metal and pipe, shown by tensile and transverse tests of each.
2. Greater elasticity, thus increased resistance to shock.
3. Weight reduced, length for length.
4. Perfect uniformity in length.
5. Beads cast on as part of the pipe.
6. Less wall thickness with greater strength.
7. Practically no weight variation.
8. Human element in the manufacture of "Sand-Spun" pipe greatly assisted by machinery, thus insuring a uniform product.
9. No casting strains in the process of manufacture or in the product.
10. Close grained iron and homogeneous throughout—free from inclusions and blow holes.
11. Clean insides.

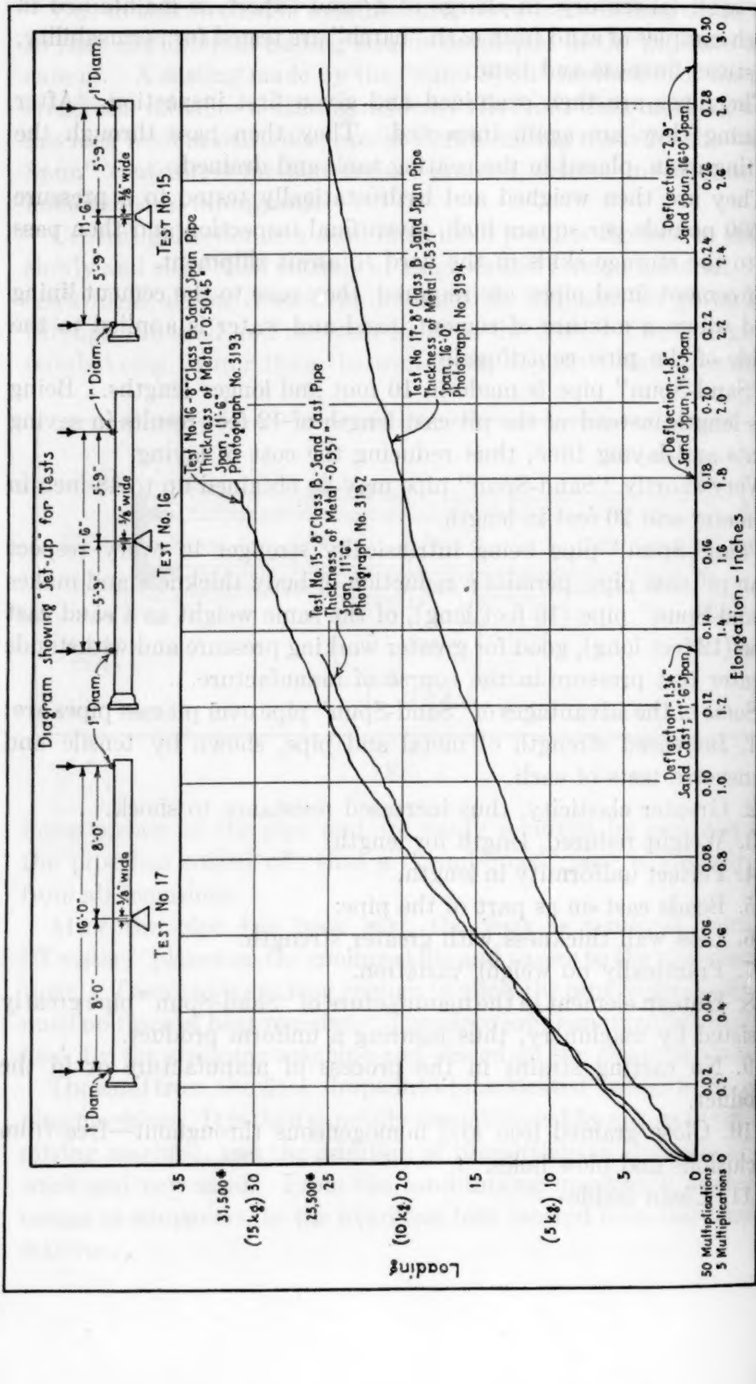
Diagram showing "Set-up" for Tests
Test No 17
16'-0"
8'-0"
8'-0"
1" Diam.
3/8" wide
Test No. 16
11'-6"
5'-9"
5'-9"
1" Diam.
3/8" wide
Test No. 15
11'-6"
5'-9"
5'-9"
1" Diam.
3/8" wide
Test No 16 - 8" Class B Sand Spun Pipe
Thickness of Metal 0.5045"
Span, 11'-6"
Photograph No. 3193
Test No. 15 - 8" Class B - Sand Cast Pipe
Thickness of Metal - 0.537"
Span, 11'-6"
Photograph No. 3192
Test No 17 - 8" Class B - Sand Spun Pipe
Thickness of Metal - 0.537"
Span, 16'-0"
Photograph No 3194
Deflection - 1.34" Sand Cast; 11'-6" Span
Deflection - 1.8" Sand Spun, 11'-6" Span
Deflection - 2.9" Sand Spun, 16'-0" Span
Loading
35
31,500# (15 kg) 30
25,500# 25
(10 kg) 20
15
(5 kg) 10
5
0
50 Multiplications 0 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30
5 Multiplications 0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0
Elongation - Inches

Fig. 5

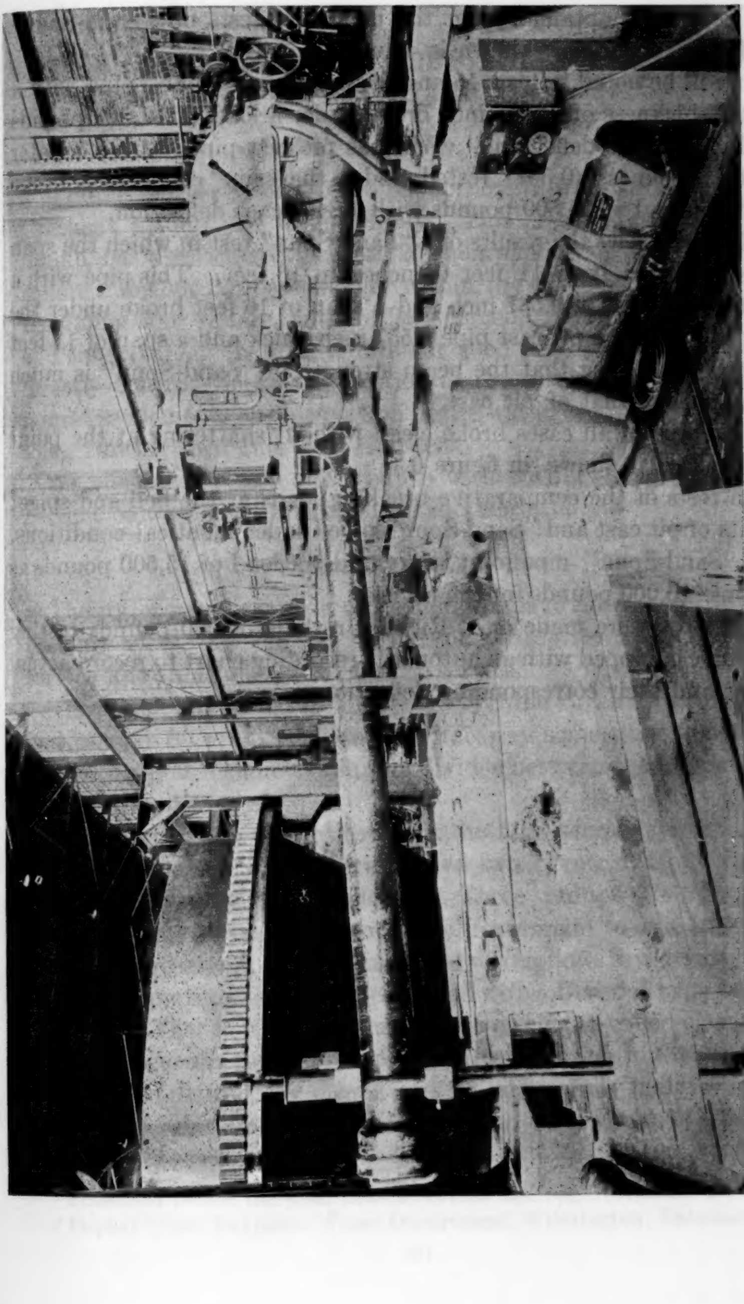

FIG. 6

COMPARATIVE TESTS OF "SAND-SPUN" AND "PIT-CAST" PIPE

The results obtained from the deflection tests on "Sand-Spun" and pit cast pipe are shown in figure 5.

It will be noted in tests 15 and 16, that "Sand-Spun" pipe with a metal thickness of 0.5045 inch broke under a load of 31,500 pounds with 1.8 inches deflection. Whereas pit cast pipe, with a greater metal thickness (0.557) tested under the same conditions, broke under a load of 25,500 pounds with 1.34 inches deflection.

Test 17 shows the results of a "Sand-Spun" test in which the span was increased from 11 feet 6 inches to 16 feet. This pipe with a metal thickness of 0.537 inch and a span of 16 feet broke under the same load as the pit cast pipe 0.557 inch thick and a span of 11 feet 6 inches, showing that the beam strength of "Sand-Spun" is much greater than that of pit cast.

The pipe in all cases broke clean without shattering at the point of fracture as shown in figure 6.

In tests of the comparative breaking loads at the bell and spigot joints of pit cast and "Sand-Spun" pipe, under identical conditions, the "Sand-Spun" pipe joint broke under a load of 15,500 pounds as against 10,000 pounds for the pit cast.

All tests were made on a Riehlé Brothers 50,000 pounds testing machine equipped with an automatic recording chart to record actual loads and their corresponding deflection.

THE OLD MILL STREAM PROJECT, WILMINGTON, DELAWARE[1]

By W. Compton Wills[2]

Wilmington, a city of 110,000 population, utilizes the Brandywine Creek as a source of water supply. This creek, above the city's intake, has a watershed area of 325 square miles, of which only 18½ square miles, or 5.5 percent, lies within the State of Delaware; the remaining 306½ square miles, or 94.5 percent, lying within the State of Pennsylvania. Not only does our good neighbor, Pennsylvania, directly control the greater portion of the watershed, but also the largest settlements on this portion of the watershed, namely, Coatesville, Dowingtown and West Chester.

We should stop and offer thanks within a few days for this 5.5 percent of watershed area allotted to Delaware.

PRESENT SUPPLY SYSTEM

The water supply system of Wilmington is divided into two main pressure zones, the high service and the low service, and an auxiliary service known as the extreme high service.

The water is diverted from the Brandywine Creek at a small dam and carried by gravity by an open raceway some three-quarters of a mile to a point where the supply divides between the high and low service systems.

That part of the flow utilized for the high service system enters a pumping station wherein are located two 12 m.g.d. Holly vertical triple expansion pumping engines. These pumps lift the water about 260 feet through a 42-inch steel force main to a 35 m.g. sedimentation reservoir, after which the water flows by gravity to a 12 m.g.d. slow sand filter plant equipped with a Blaisdell type washing machine. Thence it passes to a 6 m.g. capacity so-called clear water reservoir beneath the filter beds and after chlorination flows to the high service districts by means of a 48-inch supply main, a part of this supply being stored south of the Brandywine Creek in a 7.5 m.g. emergency reservoir.

[1] Presented before the Four States Section meeting, November 21, 1930.

[2] Deputy Chief Engineer, Water Department, Wilmington, Delaware.

The supply for the extreme high service is repumped from the high service to a tower having a storage capacity of a half million gallons.

The balance of the supply passes on to the low service system, first passing through two coagulating basins of 2 m.g. capacity and a 12 m.g.d. rapid sand filter plant. It is then chlorinated and flows by gravity to a pumping station wherein are located three De Laval steam turbine driven centrifugal pumps, two of 9 m.g.d capacity and one of 12 m.g.d. capacity (the 12 m.g.d. turbine being a reserve unit for use in connection with the high service). Finally, the water is lifted 150 feet to a 40 m.g. capacity distributing reservoir.

PROPOSED FUTURE SUPPLY

The most recent improvements in the supply system, namely, the construction of the rapid sand filter plant, the 7.5 m.g. emergency reservoir, the installation of the steam turbine driven pumps, resulted from recommendations following a comprehensive study of the system made in 1916. At this time the necessity was recognized of taking measures to insure against water shortage in the Brandywine Creek during periods of drought. In 1919 the necessity of augmenting the normal flow of the Brandywine during dry weather periods was reported on.

As a first move to guard against water shortage in the Brandywine Creek, in 1923 additional water rights were secured, permitting the city to enjoy the full flow of the Brandywine at the city dam. In 1924 a further move was made by inaugurating a study to disclose a method of supplementing the normal flow of the Brandywine. This study proceeded until 1929, resulting in the development of the Old Mill Stream Project.

For five years the study was carried on jointly by the engineering firm of Messrs. Fuller and McClintock and department engineers.

Streams in this vicinity were studied as to possibilities of constructing impounding reservoirs on them, and means by which this storage could be utilized in the existing system.

During this time detailed reports were submitted on six projects. Two of these projects were on the Brandywine Creek, one on the upper reaches of the Christiana River, a site some twelve miles to the south of Wilmington; one on White Clay Creek, a site some 15 miles to the southwest of Wilmington; one on Red Clay Creek, at a location about 6 miles northwest of Wilmington; and finally the Old Mill

Stream Project. Other Brandywine sources, including one in Pennsylvania, were studied in a general manner.

For various reasons, five of the sites were discarded. The Board reluctantly relinquished its desire to construct the Red Clay Creek Project, but was forced to do so principally because it was unable to justify the costs of the relocation of a portion of a secondary line of the Baltimore and Ohio Railroad known as the Landenberg Branch.

Old Mill Stream Project

The Old Mill Stream Project finally accepted for development and now under construction by the city, at an estimated cost in the neighborhood of $2,500,000, to supplement the dry weather flow of the Brandywine Creek, uses the excess flows in the Brandywine Creek by storage in a reservoir on a branch of Red Clay Creek. The development of this project necessitated the acquiring of the necessary land for the reservoir; the construction of a concrete masonry dam; the construction of a 42-inch force main; the abandonment or relocation of many existing roads; the installation of a new pumping station; and finally the clearing of the valley.

About 480 acres of land comprising parcels from eleven owners were secured during 1929 and the early part of 1930.

In October, 1929, a contract was awarded to John L. Walsh of Northport, L. I. for the construction of the Old Mill Stream Dam for $1,090,000. The dam is to be constructed of concrete masonry, gravity section, approximately 900 feet in length, some 135 feet high measured from the bottom of cut-off wall to crest; about 87 feet thick at the base of the maximum section, with a thickness of about 16 feet at the top.

This dam will form a reservoir having a maximum depth of about 100 feet, a length of about 8,000 feet and a cubic capacity of about 2,000 million gallons.

Excavation for this dam, amounting to some 70,000 cubic yards, was started in December, 1929; concrete placement was started in June of this year. At this time, excavation, aside from backfill, is completed; approximately 85,000 cubic yards of concrete, or equal to 80 percent of the required masonry, have been poured.

Bulk cement is being used in the construction of the dam; sand and gravel are being trucked from Wilmington; concrete is being conveyed from a central mixing plant located below the dam to the dam by belt conveyors.

Cement tests are made by the Pittsburgh Testing Laboratories. Concrete compression tests of each pour are made at the University of Delaware.

Last month a contract was awarded the Lock Joint Pipe Company of Ampere, N. J. for $480,000, to construct some 31,000 feet of 42-inch steel cylinder reinforced concrete pipe. This pipe line is to connect the present 42-inch raw water line to the slow sand filters and the impounding reservoir by way of the proposed pumping station to be located just below the Old Mill Stream Dam, thus permitting the existing Holly pumps to lift Brandywine Creek water, during periods of high flows, through this new line to the storage reservoir. The water is later to be returned to the high or low service systems, as occasion requires, by proposed pumps in the new pumping station below the dam, capable of lifting some 18 m.g.d. over the dividing ridge. Double pumping is justified, economically, in making the best of the natural facilities offered by the topography of this region.

In order that portions of existing highways may be inundated, several changes must be made in the present roads. It becomes necessary to vacate three and one-quarter miles of road; to provide a new and improved road one-half mile in length; to raise an existing road and improve it for a distance of three-quarters of a mile; and finally to construct new dirt roads three-quarters of a mile in length. The Levy Court of New Castle County, the body having jurisdiction over these roads, and the City have agreed as to the extent and nature of the road changes, and the returns of a road commission appointed by the Resident Judge of this County have been confirmed by the proper court. At present, contract drawings and specifications for these road changes have been drafted and it is hoped that they will soon be placed under contract.

Design and supervision of the project are by Messrs. Fuller and McClintock, with department engineers in charge in the field. Dr. R. J. Colony of Columbia University has acted as consultant on geology in connection with the dam. Preliminary core borings for the dam were made by Sprague and Henwood of Scranton, Pa.

CONCLUSION

The Old Mill Stream Project when completed in conjunction with the existing system should provide a water supply for the city of Wilmington which would be adequate and safe at all times for a good many years to come.

GAS PRODUCTION AND pH DETERMINATION OF COLI-AEROGENES CULTURES IN SUGAR BROTHS[1]

By C. C. Ruchhoft, J. G. Kallas and Ben Chinn[2]

Proposed changes in the Coli-aerogenes section of Standard Methods (1925) have recently been submitted by the referee for the American Public Health Association and are discussed by Norton (1930). It is pointed out by Norton that many plant men use methods other than standard. This is because Standard Methods do not prove practical from their standpoint. In the laboratories of the Sanitary District about 14,000 bacteriological examinations of water and sewage are made annually and we have the viewpoint of the practical plant man on this work.

The recommendation in standard methods that all lactose broth tubes showing gas be tested for the Coli-aerogenes group after twenty-four hours is not consistently followed and does not seem practical from our standpoint. Only 60 percent of our total positive presumptive tests show any gas in twenty-four hours. The other 40 percent invariably show gas in forty-eight hours in higher dilutions than the twenty-four-hour presumptives. This practice, therefore, would greatly increase our routine work without adding materially to the positive confirmed results in the highest dilution positive presumptive tubes. While a pH lethal for members of the Coli-aerogenes group often results in standard lactose broth presumptives, we would prefer to correct this difficulty by buffering sufficiently to maintain a higher non-lethal pH after forty-eight hours.

Clark (1915) studied the final hydrogen ion concentration of Bact. coli group cultures in various media and reported that the amount of buffer is proportional to the final pH. Salle (1927) also studied the limiting hydrogen ion concentration obtained in buffered lactose broths and the effect of the buffer

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[1] Presented before the Illinois Section meeting, April 24, 1930.

[2] Principal, Senior and Junior Bacteriologist, Sanitary District of Chicago. Chicago, Ill.

salt and lactose concentrations with cultures of Bact. coli and Bact. aerogenes. Cohen and Clark (1919) showed that the Coli-aerogenes group maintained maximal growth rates over a pH range of 5.0 to 8.0 in buffered broth, and that the aerogenes section maintained slightly higher average rates of growth over a somewhat wider range. Butterfield (1929) determined the amount of buffer salt necessary to produce maximum counts of Bact. aerogenes in a dilute dextrose broth and found that marked growth inhibition results with either too little or too much buffer. Norton and Barnes (1929) found that when Cl. welchii are present a pH of 4.2 to 4.3 may be reached in twenty-four hours in standard lactose broth and that the recovery of the Coli-aerogenes group may be interfered with. Thompson (1927) used buffered lactose broth to prevent such interference and reported good results. Janzig and Montank (1928) recommend a pH adjustment of 8.0 without buffering on standard lactose broth for the elimination of false presumptive tests.

Our studies have been made with Coli-aerogenes group cultures obtained from routine water samples by the standard procedure to complete confirmation. Only cultures which were reported as pure Gram-negative non-spore forming after the stain examination were included. Other studies have shown us that these cultures are nevertheless not all pure. Many of them are mixtures of Bact. coli or Bact. aerogenes with other bacteria as contaminants and some contain both Bact. coli and Bact. aerogenes. We used these cultures without further purification because we desired to study cultures such as are ordinarily obtained in water work rather than pure laboratory strains. These cultures were later purified 5 to 7 times and the final pure strains of Bact. coli and Bact. aerogenes were used for certain phases of the work. Hereafter the confirmed cultures will be referred to as Coli-aerogenes cultures and the purified strains as Bact. coli or Bact. aerogenes, as the case may be.

The Coli-aerogenes cultures were transferred in groups of about 40 strains from tryptophane broth tubes to the various test media. Standard lactose broth and brilliant green lactose peptone bile broth with various quantities of K_2HPO_4 buffer and initial pH adjustments were used in the first part of the work. The brilliant green bile medium had the composition recommended by H. E. Jordan (1928) and contained 2 percent bile with one part of brilliant green in 70,000. Ruchhoft and Kallas (1930) have reported favorably upon this medium for Coli-aerogenes confirmation after an extensive study. Gas readings were made in all test media after eighteen-, twenty-four-, forty-two- and forty-eight-hour incubation periods at 37°C. pH measurements were made on all cultures after forty-eight hours at

37°C. using the method of Hurwitz and Kraus (1929). We shall present the data on the pH first and then consider the gas production in the various broths.

FINAL pH RESULTS

The pH determinations of 158 Coli-aerogenes cultures after forty-eight hours at 37°C. in standard lactose broth examined in groups of 40 showed that there was practically no variation in the average, maximum or minimum result of each group. The ninimum final pH of the 158 cultures was 4.3, the maximum was 5.7 and the average was 4.75. The initial pH of the standard lactose broth did not affect

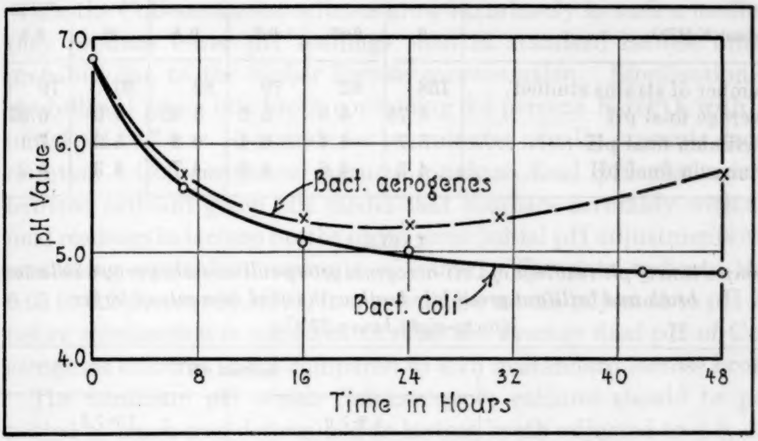

FIG. 1

the final pH of these cultures. Forty Coli-aerogenes cultures were planted into lactose broths having initial pH adjustments of 6.2, 7.0 and 8.0. The average, maximum and minimum final pH readings were practically the same for all three broths. An investigation of the rates of change of the pH by the Coli-aerogenes group cultures in lactose broths of various initial pH adjustments showed that pH parity was reached in all broths in about 16 hours. Figure 1 shows the average pH curve of 26 Bact. aerogenes cultures and 39 Bact. coli cultures in standard lactose broth at 37°C. during the first forty-eight hours. If the initial pH of the medium is changed only the first section of these curves up to about the sixteenth hour are changed.

The final pH in lactose broth can be increased by buffering the

media. Table 1 shows the results when lactose broth is buffered and the initial pH is adjusted at 6.8 to 7.0 and 7.6 to 7.8. This study shows that 0.2 percent of K_2HPO_4 in lactose broth with an initial adjustment of 6.8 to 7.0 raises the average final pH about 0.7 of a unit to 5.6. When a buffer is used an increase in the initial pH

TABLE 1

Comparison of pH readings of Coli-aerogenes group cultures in lactose broth when buffered with various amounts of K_2HPO_4 after forty-eight hours' growth at 37°C.

	INITIAL pH ADJUSTMENT					
	6.8–7.0				7.6–7.8	
Percent K_2HPO_4	0	0.05	0.2	0.4	0	0.2
Number of strains studied	158	82	79	82	40	79
Average final pH	4.75	4.9	5.6	5.45	4.6	6.35
Maximum final pH	5.7	6.1	6.4	6.2	5.0	7.1
Minimum final pH	4.3	4.6	4.8	4.7	4.3	5.2

TABLE 2

Comparison of pH readings of Coli-aerogenes group cultures when grown in lactose broth and brilliant green bile broth with equal amounts of buffer (forty-eight hours 37°C.)

	INITIAL pH							
	6.8–7.0				7.6–7.8			
Percent K_2HPO_4	0.05		0.4		0.05	0.2		0.4
Media	L. B.	B. G. B.	L. B.	B. G. B.	B. G. B.	L. B.	B. G. B.	B. G. B.
Number of strains studied	82	42	82	62	44	79	38	81
Average final pH	4.9	5.5	5.45	5.5	5.8	6.35	6.0	5.8
Maximum final pH	6.1	6.2	6.2	6.2	6.5	7.1	6.3	6.3
Minimum final pH	4.6	4.7	4.7	5.0	4.7	5.2	5.7	5.0

adjustment also increases the final pH reading. Seventy-nine Coli-aerogenes cultures planted into a lactose broth buffered with 0.2 percent K_2HPO_4 and adjusted from 7.6 to 7.8 had an average final pH of 6.35 compared to 4.75 in standard broth.

The final pH readings of the Coli-aerogenes cultures grown in the

variously adjusted and buffered brilliant green lactose peptone bile broths are interesting and are shown in table 2 compared to the results in lactose broth. No final pH measurements could be made on unbuffered brilliant green bile broth with the method used due to color interference. With buffered broth, however, there was sufficient color reduction during the incubation period so that no difficulty was encountered in making the pH readings. However, the preparation of the buffered brilliant green bile requires special care to prevent a change in the medium with a decolorization of the dye during sterilization, especially at the higher initial pH adjustment and with 0.4 percent K_2HPO_4. When decolorization does occur the inhibiting action of the medium on spore-forming organisms is largely lost. While the Coli-aerogenes cultures grow luxuriantly in such a medium they produce lower pH readings than in standard lactose broth, probably due to the higher lactose concentration. Sterilization of the brilliant green bile broth containing 0.4 percent K_2HPO_4 with an initial pH of 7.8 at 10 pounds for ten minutes usually prevents decolorization. Coli-aerogenes cultures produce final pH readings in buffered brilliant green bile media that compare favorably with the final readings in lactose broths of the same initial pH adjustments and containing equivalent amounts of buffer. The data indicate that 0.05 to 0.2 percent K_2HPO_4 in a green bile media adjusted to pH 7.0 before sterilization is sufficient to raise the average final pH of Coli-aerogenes cultures to 5.5 compared to 4.75 in standard lactose broth.

The minimum pH which Coli-aerogenes cultures should be permitted to reach was determined in lactose broth adjusted to 4.0, 4.5, 4.8, 5.0 and 5.2. Beck (1930) found that the reduction of pH in standard and buffered lactose broths by our Coli-aerogenes cultures was due to the production of acetic and propionic acids in the ratio of about 10 to 1, respectively, with traces of higher acids. The lactose broth was adjusted with similar acid, sterilized, planted with Bact. coli and Bact. aerogenes cultures and incubated at 37°C. There was not sufficient growth of these organisms in lactose at 4.8 or lower to produce any gas in forty-eight hours. Some of the strains were killed by forty-eight hours' exposure at a pH of 4.8 in a lactose broth adjusted with products of their own metabolism. All of the Bact. coli strains and most of the aerogenes were viable after twenty-four hours at 4.5, but only about 20 percent of each remained viable after forty-eight hours at this pH. We believe that if lactose broth is buffered sufficiently to prevent final pH readings below 4.8 in forty-

eight hours satisfactory results will be obtained. Our data indicate that buffering lactose broth and brilliant green bile broth with 0.2 and 0.1 percent of K_2HPO_4, respectively, should be sufficient for this purpose. Titration curves have shown that 0.2 percent K_2HPO_4 in standard lactose broth will require the production of twice as much acid to reach 4.8 as an unbuffered broth.

GAS PRODUCTION

The effect of buffering these media on the gas production of the Coli-aerogenes group cultures has been as interesting, if not as important, as its effect on the pH trends. Table 3 shows the average percentage of gas produced by Coli-aerogenes group cultures in these media for various incubation periods from eighteen to forty-eight hours. It is evident that buffering increases the growth rates and consequently the gas production during the first twenty-four hours' incubation. There is a very decided increase in the average percent of gas formed in eighteen and twenty-four hours in the brilliant green bile medium buffered with 0.05 to 0.2 percent K_2HPO_4. The average percent increase in gas formation due to buffering is greater in every case in brilliant green bile than it is in lactose broth. For lactose broth 0.2 percent buffer salt and an initial pH of 7.6 appears to be the optimum condition for gas production.

TABLE 3

Gas production in lactose broth and brilliant green bile broth with Coli-aerogenes cultures (37°C.)

	INITIAL pH											
	6.8–7.0								7.6–7.8			
Percent K_2HPO_4........	0		0.05		0.2		0.4		0.05	0.2		0.4
Media............	L. B.	B. G. B.	L. B.	B. G. B.	L. B.	B. G. B.	L. B.	B. G. B.	B. G. B.	L. B.	B. G. B.	B. G. B.
Number of cultures.	115	115	81	81	39	37	81	83	83	39	38	81
Average per cent gas in:												
18 hours........	19.3	18.4	31.5	32.0	34.0	53.0	40.6	37.7	33.3	49.2	49.0	32.3
24 hours........	25.6	24.3	38.4	61.3	41.3	68.7	49.6	53.0	47.2	55.3	63.7	47.0
42 hours........	37.4	35.6	49.7	68.2	54.9	73.0	58.0	71.7	69.8	61.3	74.5	73.0
48 hours........	39.1	37.2	51.2	69.4	56.8	74.4	60.4	72.3	71.3	61.5	74.5	73.8

With brilliant green bile the best gas production seems to occur with the same amount of buffer and an initial pH adjustment of 7.0. The advantages and disadvantages obtained by buffering these media are more strikingly shown in table 4. It will be noted that the percentage of culture showing over 50 percent gas is increased remarkably by buffering in both lactose broth and brilliant green bile. There is, of course, a corresponding decrease in the percentage of positive cultures or those containing between 10 to 50 percent gas. With lactose broth there is apparently a slight increase in the percentage of doubtful tests showing from a bubble to 10 percent gas, while with brilliant green bile there is practically no change in this group. There is, however, an increase in the cultures which produced no gas in forty-eight hours from 3 to 4 percent.

TABLE 4

Comparison of forty-eight-hour 37°C. gas readings on Coli-aerogenes cultures grown in standard and buffered lactose and brilliant green bile broths

	STANDARD NOT BUFFERED		BUFFERED WITH 0.05 TO 0.4 PERCENT K_2HPO_4	
Media	L. B.	B. G. B.	L. B.	B. G. B.
Number of cultures used	266	439	410	735
Percent of cultures with following gas readings:				
++ over 50 percent	17	27	62	88.5
+ 10 to 50 percent	78	67.5	29	4.8
± Bubble to 10 percent	2.0	2.5	5.0	2.7
− No gas	3.0	3.0	4.0	4.0

We believe that in practical work the advantages gained by preventing the greater reduction in pH more than offsets this 1 percent loss due to slow gas formers. The chances are that these slow-growing strains would also be outgrown and lost due to pH reduction in standard unbuffered broth.

To study the effect of buffering on the spore-forming lactose-fermenting organisms often encountered in water work, such organisms were isolated from sewage and 86 cultures were made in 0.2 percent buffered lactose and brilliant green bile broth. It was found that 97 percent of them produced gas in lactose broth while only 35 percent of them produced gas in brilliant green bile. Increasing the

initial pH from 7.0 to 7.8 decreased the amount of gas produced in lactose broth and increased the amount of gas in brilliant green bile broth. When these cultures were mixed with Coli-aerogenes group cultures and planted into 0.2 percent buffered lactose and brilliant green bile broth, gas was produced in every case and the Coli-aerogenes group cultures were recovered on Endo, E.M.B. and Salle's agar plates. This study showed that there is a difference in the effect of buffering and initial pH adjustment in lactose broth and brilliant green bile broth. In lactose broth, increasing the initial pH from 7.0 to 7.8 and also the amount of buffer apparently favors the enrichment of the Coli-aerogenes group and hinders or has little effect on the growth of spore-forming lactose fermenters. In brilliant green bile, on the other hand, this increase in buffer and initial pH decreases the inhibiting power and selective action of the medium, for the Coli-aerogenes group and consequently the spore-forming organisms grow more frequently.

While we have been considering the Coli-aerogenes group as a whole there is a considerable difference in the gas production and reactions produced by the two sections of this group in the media we have studied. The results obtained with mixtures of Bact. coli strains and Bact. aerogenes strains may also differ. We have found that many of our highest dilution positive presumptive results on polluted waters and sewage actually contain both Bact. aerogenes and Bact. coli and sometimes even Bact. coli, Bact. aerogenes and spore-forming lactose fermenters. Tonney and Noble (1930) found that the Coli-aerogenes group in polluted water and sewage consisted of about 50 percent Bact. coli and 50 percent Bact. aerogenes when counts are made with cyanide citrate agar. We have tried their method with similiar results and find that both Bact. coli and Bact. aerogenes may be present in the highest dilution positive tube frequently in polluted waters. This fact does not seem to be generally recognized.

The results with pure Bact. coli strains[3] and Bact. aerogenes strains in the test media are shown in table 5. In all of these media, except the buffered lactose broth, Bact. coli strains produce less gas than Bact. aerogenes strains in forty-eight hours at 37°C. Buffering

[3] For simplicity we are including only strains which conform to the following differential tests as pure true Bact. coli and Bact. aerogenes: Bact. coli – Indol + Methyl Red + Voges-Proskauer – Citrate –; Bact. aerogenes Indol – Methyl Red – Voges-Proskauer + Citrate +.

increases the amount of gas formed in both lactose broth and brilliant green bile media by Bact. coli strains and also in brilliant green bile by Bact. aerogenes strains. The twenty-four to forty-eight-hour gas ratios show that the brilliant green bile broth inhibited the normal amount of gas formation with both Bact. coli and Bact. aerogenes cultures during the first twenty-four hours. Buffering the brilliant green bile broth increases the gas formed in twenty-four hours by both types of organisms. Buffering standard lactose broth increases the ratio of the gas formed in the first twenty-four hours with the aerogenes section. Data as shown in table 5 were also obtained at 45°C. and practically the same results were obtained as far as twenty-four- to forty-eight-hour gas ratios and total percentage of gas formed were concerned. There was a greater lag period before active gas production was started at 45°C. with the Bact. aerogenes strains. With Bact. coli cultures this lag was not evident and gas production was very rapid before eighteen hours. In buffered lactose broth these Bact. coli strains produced an average of 78 percent gas in eighteen hours.

TABLE 5

Gas production results in standard and buffered lactose and brilliant green bile broths with pure strains of Bact. coli and Bact. aerogenes at 37°C.

(Average results 10 pure strains of each section)

MEDIUM	AVERAGE PERCENTAGE OF GAS FORMED IN 48 HOURS		RATIO OF GAS FORMED, 24 HOURS/48 HOURS	
	Bact. coli	Bact. aerogenes	Bact. coli	Bact. aerogenes
Standard lactose broth	37	77	0.96	0.68
Lactose broth, 0.2 percent K_2HPO_4, initial pH 7.0	78	73	0.96	0.87
Brilliant green bile broth	40	70	0.77	0.46
Brilliant green bile broth, 0.2 percent K_2HPO_4, initial pH 7.0	63	77	0.92	0.60

Coli-aerogenes cultures obtained by the standard procedure usually produce results which may be anywhere between the results obtained with pure Bact. coli and pure Bact. aerogenes, as shown in table 5. This is the result of mixtures of Bact. coli with Bact. aerogenes or mixtures of either one with other non-members of the colon group. Our studies indicate that the actual numbers of Bact. coli and Bact.

aerogenes present at the start have less effect on the final result than the ability of the particular strains to reproduce in the medium. Most mixtures of coli and aerogenes in lactose and dextrose broths will indicate the pH of the Bact. coli strain for seventy-two hours or longer. For this reason liquid media which are designed for presumptive tests with the additional feature of Coli-aerogenes differentiation, depending upon an indicator for a pH determination, are apt to give misleading results. This point is shown by an experiment with the methylene blue brom cresol purple medium of Lauter and Dominick (1929). This medium was designed to inhibit Bact. aerogenes to a greater extent than Bact. coli and to give gas and a color change indicative of the organism present. Out of 53 samples of sewage and sewage plant effluents planted into this medium, Bact. coli reactions were obtained 44 times in the highest positive dilution or in 83 per cent of the samples. This indicates that the medium does inhibit Bact. aerogenes to a greater extent than Bact. coli for we have found that these organisms are usually present in equal numbers in such samples. Our results indicate that some of these Bact. coli reactions were obtained when both Bact. coli and Bact. aerogenes were present and some were due to Bact. aerogenes and organisms not belonging to the Coli-aerogenes group which produce acid from lactose. Experiments with pure cultures and mixtures of pure Bact. coli and pure Bact. aerogenes cultures have confirmed this.

METHYL RED-VOGES-PROSKAUER TESTS

The methyl red test is a colorimetric pH determination in a buffered dextrose broth and the Voges-Proskauer test has become associated with it in Coli-aerogenes differentiation. These tests are tentatively recommended by Standard Methods (1925) for differentiation of fecal from non-fecal members of the Coli-aerogenes group. The referee has recommended that this section on fecal and non-fecal differentiation be omitted, but the committee did not approve of this recommendation, Norton (1930). This indicates that there may be some difference of opinion as to the value of these tests and that perhaps a little more study of the subject is required.

As stated above, we have found that many "pure Gram-negative non-spore forming cultures" obtained by standard methods are not pure. Some of these mixtures contain both Bact. coli and Bact. aerogenes, one of these may be very much in the minority. It is therefore interesting and important to know how the methyl red and

Voges-Proskauer tests come out with such cultures. Thirty-nine pure Bact. coli strains were mixed with 39 pure Bact. aerogenes strains and 39 cultures each containing one member of each section of the group were obtained. These 39 mixed cultures were then each planted into 5 tubes of Difco[4] M.R.-V.P. medium so that the tests could be made with various incubation periods from one to five days. Each day before the tests subcultures were made for recovery of the Bact. coli and Bact. aerogenes strains from the mixtures.

TABLE 6

Results of growth of Bact. coli and Bact. aerogenes in dextrose peptone phosphate broth (methyl red-Voges-Proskauer medium)

39 laboratory mixtures used

	INCUBATION PERIOD AT 37°C.				
	1 day	2 days	3 days	4 days	5 days
Total number of mixtures	39	39	39	39	39
Number of Bact. coli recovered	39	39	39	37	36
Number of methyl red + cultures indicating Bact. coli	34	31	32	29	26
Number of Bact. aerogenes recovered	39	39	36	36	36
Number of Voges-Proskauer + indicating Bact. aerogenes	14	17	15	20	18
Number of cultures from which both members of group were recovered	39	39	36	36	36
Number of cultures in which both members of group were indicated by methyl red + and Voges-Proskauer +	9	9	8	10	5

These various incubation periods were used because standard methods recommended four days, the manufacturers of the medium recommend two days and other workers have recommended various periods up to five days. The results as shown in table 6 are very much the same regardless of the period of incubation. For on each day the number of methyl red positive readings and the number of

[4] Comparative tests indicated that this medium was very satisfactory and was even superior to the dextrose peptone phosphate broth prepared in our laboratory for the Voges-Proskauer test.

Voges-Proskauer positive tests are smaller than the number of Bact. coli and Bact. aerogenes strains respectively that were recovered. The percentage of cultures which indicated Bact. coli strains by methyl red positive results dropped from 89 after one day to 67 after five days. The percentage of cultures which indicated Bact. aerogenes strains varied from 37 to 51. Both methyl red positive and Voges-Proskauer positive tests were obtained from 13 to 25 percent of the cultures. We conclude that with cultures such as these and the ordinary incubation periods of from two to four days at 37°C. in dextrose peptone phosphate broth or its equivalent, indications of Bact. coli only will be obtained 55 percent of the time, Bact. aerogenes only 20 percent of the time and both types 25 percent of the time. Paine (1927) and Williams and Morrow (1928) explain the failure of the Voges-Proskauer reaction on the basis of the bacterial destruction of acetyl methyl carbinol. Regardless of the cause of the failure of the Voges-Proskauer reaction in these mixtures we wish to point out that all of these Bact. aerogenes strains produced the reaction when grown in pure culture. All of the Bact. coli strains produced methyl red positive reactions in forty-eight hours in pure culture. We have found that other bacterial contaminants of Bact. coli sometimes prevent the methyl red positive test in the same way as Bact. aerogenes do in these mixtures.

SUMMARY

Studies made with Coli-aerogenes group cultures, Bact. coli strains and Bact. aerogenes strains in buffered lactose and brilliant green bile broths have shown that the use of buffered broths have a decided advantage over unbuffered in maintaining a higher final non-lethal pH. The addition of 0.2 percent K_2HPO_4 as the buffer in broths with an initial pH adjustment of 7.0 to 7.2 produces a final average pH of 5.6 compared to 4.75 in standard broth. Buffering increases the bacterial growth rates of these cultures and also the amount of gas produced both in lactose broth and brilliant green bile broth. Optimum gas production is obtained in lactose broth with 0.2 percent K_2HPO_4 and an initial pH of 7.6, while in brilliant green bile the same amount of buffer is needed with an initial pH of 7.0. With mixed cultures of spores and members of the Coli-aerogenes group an initial pH of 7.8 with buffer favors the Coli-aerogenes group in lactose broth but has little inhibitive effect on the spores. In brilliant green bile, however, the inhibitive power of the medium for

spore-formers is decreased by increasing the pH above 7.0 and by increasing the buffer above 0.2 percent K_2HPO_4. For optimum results with brilliant green bile as a confirmatory medium for the Coli-aerogenes group considering the maintenance of a non-lethal pH for forty-eight hours, the gas productivity and the inhibition of spores, an initial adjustment of 7.0 with 0.05 to 0.2 percent K_2HPO_4 is recommended. The data indicate that buffering of these media should facilitate the routine method of water analysis.

Evidence is presented to show that the methyl red and Voges-Proskauer tests are not reliable on routine cultures of the Coli-aerogenes group obtained by standard methods. Either test may be interfered with due to the presence of either organism as a contaminant of the other.

The authors wish to acknowledge the helpful suggestions and criticism of Dr. F. W. Mohlman, Director of Laboratories, under whose direction this work was carried out.

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DISCUSSION

R. E. THOMPSON:[5] The authors are to be congratulated on the work which they have carried out in connection with proposed changes in the Coli-Aerogenes Section of Standard Methods of Water Analysis. Their observations demonstrate anew the advisability of adopting some means of controlling the H-ion concentration of liquid media from which it is hoped to recover B. coli group organisms.

If the practice at the Sanitary District of Chicago of examining the presumptive tubes only after forty-eight hours' incubation were adopted at Toronto, the use of a buffering agent in the standard lactose broth would be imperative in order to secure reliable results. The examination of the presumptive tubes after twenty-four hours' incubation, however, does not entail a great deal of additional work at Toronto as the vast majority of positive tubes show gas in twenty-four hours. This is a good illustration of the fact that a routine procedure which gives satisfactory results with one water supply may not be equally applicable in other sections of the country.

When the writer reported (Jour. Bact., xiii, 209–21; THIS JOURNAL, 18, 281) on the successful use of standard lactose broth modified by the addition of 0.2 percent dipotassium phosphate for deferring the rapid destruction of colon group organisms by the acidity produced during preliminary enrichment, it was believed that the lethal acidity resulted from the growth of the colon group organisms themselves.

[5] Bureau of Laboratories, Department of Water Supply, Toronto, Can.

Additional information secured since that time, however, would indicate that the pH value of the medium was brought into the lethal zone by other organisms present in the water.

Several references are made to such interfering organisms in current literature. Thus Norton and Barnes (THIS JOURNAL, 19, 729–30) found that viable organisms were always present in lactose broth cultures of B. coli after forty-eight hours' incubation, the pH value at that time being 5.0 to 5.3, whereas when Cl. welchii, which in pure culture in lactose broth produced pH values of 4.2 to 4.5 in forty-eight hours, was simultaneously inoculated into the broth with B. coli, recovery of the latter organism was uncertain, particularly after forty-eight hours' incubation. These investigators found that after forty-eight hours' incubation of the mixed culture B. coli was never recovered when the pH value was 4.2 to 4.3, usually but not always recovered when the pH was 4.4 to 4.6, and consistently recovered at higher pH values.

Similarly, de Graaf (THIS JOURNAL, 22, 559–60) observed that the water of the Maas River gave fermentation in the Eijkman test when Witte peptone was employed in the preparation of the media but not when Poulenc peptone was used. Pure colon cultures gave fermentation in both. Investigation showed that failure to obtain fermentation when Poulenc peptone was employed was due to the additional acidity produced by streptococci present in the water which developed more readily in the Poulenc than in the Witte peptone.

The observations on the effect of buffering on gas production coincides with experience in Toronto, the volume of gas produced in the presumptive tubes being usually greater and less variable in the buffered than in the unbuffered broth.

The results obtained with buffered brilliant green bile are of great interest. Experience to date with the Toronto supply, however, indicates that the organism or organisms which interfere with the presumptive tests by producing a pH value in the medium which is lethal to colon group organisms are inhibited by unbuffered brilliant green bile. The use of the latter medium at Toronto completely eliminates the type of non-confirming presumptive positive test which the buffered broth was developed to prevent. In so far as conditions at Toronto are concerned, therefore, buffering of brilliant green lactose bile is not nearly as important as buffering of standard lactose broth.

Eugene S. Clark:[6] In considering the improvements which have recently come to the fore for the presumptive test media such as brilliant green bile broth, decrease of the hydrogen-ion concentration (increase of pH to 8.0) and buffering of the broth to the present maximum pH permitted by "Standard Methods," the last medium seems to make the greatest appeal to the laboratory which must handle samples from miscellaneous sources ranging from drinking water supplies above suspicion to highly polluted river and stream waters. The use of "Standard Methods" lactose broth has persisted because it has been supposed to favor the growth of attenuated colon-aerogenes rather than inhibiting their growth, but since a sanitary analysis involves confirmation of positive gas tubes, the presumptive broth must not only permit growth and gas production by the indices of pollution, but should also assure their isolation in the partial confirmatory tests.

In testing a polluted water we are familiar with negative endo or eosin-methylene blue readings in a lower dilution whereas positive readings are obtained in a higher dilution. Such results can be interpreted, but if the dilutions are not high enough to permit positive confirmations, negative results cannot be interpreted. Ruchhoft and associates seem to have smoothed out the uncertainties of the confirmatory tests by using buffered broth as described in their paper.

For the purpose of avoiding false presumptive tests this laboratory tried lactose broth of pH 8.1 (similar to that recommended by Janzig and Montank, 1928) making parallel tests with "Standard Methods" broth on 1140 portions from 114 samples from various sources. Thirty-two samples (320 portions) gave negative presumptive tests in both broths. Excluding 9 raw water samples, the results are tabulated as follows:

LACTOSE BROTH	PORTIONS GIVING POSITIVE PRESUMPTIVE TESTS		POSITIVE CONFIRMED TESTS FOR B. COLI	PORTIONS GIVING FALSE PRESUMPTIVE TESTS			
					Purification plants		
	24 hours	48 hours		Total	Filtered	Chlorinated	Wells, etc.
pH 6.8	55	222	78	144	28	83	33
pH 8.1	52	209	69	140	27	79	34

[6] Bacteriologist, Sanitary Engineering Laboratories, State Department of Public Health, Springfield, Ill.

There was no appreciable reduction in the number of false presumptive tests, but the samples are only representative of one seasod namely January, February and March. However, the broth of pH 8.1 gave fewer isolations of B. coli, 11 percent fewer than "Standard Methods" broth, and therefore must be seriously criticized in this instance.

In making routine analyses of samples from private wells, our laboratory has found it necessary to omit the confirmatory tests on portions which show plus gas in ordinary lactose broth at the end of twenty-four hours, because the confirmatory results were so frequently negative or inconsistent. We interpret such analyses with some misgiving and rely mainly upon descriptions of the wells as to their location and construction, which fortunately with few exceptions account for the contamination indicated by the presumptive twenty-four-hour results. Moreover, the appearance of gas *after* twenty-four hours is no assurance that a low pH lethal for coli-aerogenes will not be produced before streaks are made for the partial confirmations.

We are attempting to obtain more definite confirmations using buffered broth in a series of parallel tests with standard broth for the presumptive tests.

AN ATTEMPT TO CONTROL CYCLOPS IN A WATER PLANT[1]

By E. M. Johnson[2]

Monroe's water supply is taken from a 500,000,000 gallon impounding reservoir fed by two small streams. This reservoir was built in 1926, and was put into service in April, 1927.

The water from the dam was pumped to the plant 2 miles away by electrically driven, centrifugal pumps, and entered the mixing chamber through a hydraulically operated float controlled valve. At this point there was a wall type Wallace & Tiernan, M.S.A.M. chlorinator, with a maximum capacity of 12 pounds per twenty-four hours. The chlorine was added at this point and samples taken in mixing chamber after the water had traveled approximately 200 feet. Other samples were taken in the settling basin approximately 250 feet from the mixing chamber point of sampling. The third sampling point was from the filters.

The plant has four 0.5 million gallon, mechanical filter units, with hydraulically operated valves.

The first signs of filter-runs dropping off were observed on April 10, 1930 and on April 25 it was discovered that the filters were full of cyclops. The average monthly filter-runs dropped for three successive months; in March, 26.2 hours; April, 19.6 hours and May 13.4 hours, with turbidity, of 50 or below for each month of this period.

On April 29 the filters were partially drained and the walls and filters thoroughly treated with a concentrated solution of copper sulphate. The filters were then left over night, washed and put into service. However, this failed to kill the cyclops. On May 1, 2 and 3 prechlorination, therefore, was tried, adding the chlorine dosage of approximately 0.3 p.p.m. to the influent of the filters. This gave a residual on the filters of 0.1 p.p.m., but did not dispose of the cyclops. The extra chlorine caused a telephone call from the Coca-Cola Bot-

[1] Presented before the North Carolina Section meeting, October 14, 1930.

[2] Superintendent of Plants, Monroe, N. C.

tling Plant, stating that they were having complaints about tastes in the Coca-Cola. Therefore, prechlorinating was left off until August 16 when it was resumed. The point of application was changed to the influent of the mixing chamber. By cutting out one filter we were able to get a maximum dosage of 0.8 p.p.m. for two days. Then we had to quit two days to keep from interfering with the Coca-Cola Plant, which operated on Tuesday and Friday of each week.

After prechlorinating with a dosage of 0.8 p.p.m. for two days samples were collected, the third day from the filters. However, no cyclops were visible with the naked eye, but within three days plenty of cyclops were present. Prechlorinating was omitted from August 20 to September 13, but was resumed on the latter date and continued through October 7. The average dosage during this last period was 0.65 p.p.m.

On September 24 the filters were partially drained, treated with a concentrated solution of copper sulphate and allowed to stand two hours before being put into service. No beneficial results were obtained by this treatment.

On October 3 the filters were prechlorinated one and one-half hours with a dosage of 0.8 p.p.m., allowing rewash to run. The filters were then allowed to stand for two hours before being put into operation. Very few, if any, cyclops were killed.

The filters were prechlorinated one hour on October 6 with a 1.50 p.p.m. dosage, water flowing through rewash. This dosage killed a large portion of cyclops, but many survived the short period of chlorination.

The microscopical work was not carried out as thoroughly as it should have been, but we will mention a few microscopic organisms that were identified from the lake, although no counts were recorded. The only organism identified as plant life was the Tetraspora. Those identified as animal life were raphidomonas, euglena, rotifer and cyclops. The cyclops was the only animal life found in large numbers, and the tetraspora was found to be plentiful in plant life. These samples were collected and examined in June and August.

During the same period of time the microscopical work was being done, depth samples were taken from the lake to determine the quantity of carbon dioxide and dissolved oxygen at different depths of the lake. These samples showed the carbon dioxide contents to range from 11.0 at the bottom to 1.5 at the top, with 8.0 p.p.m. carbon dioxide at a depth of 8 feet, the point of our intake. The

TABLE 1

Prechlorination data

DATE (1930)	TURBIDITY		CHLORINE DOSAGE		RESIDUAL CHLORINE			
			Primary	Secondary	Mixing chamber	Settling basin	Filters	Effluent
			p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
May 1	25	Influent to filters	0.29	0.16			0.1*	0.1–
May 2	25		0.27	0.18			0.1*	0.1*
May 3	25		0.18	0.18			0.1	0.1*
April 29	25							
August 16	100		0.80	0.24	0.3*	0.2	0.1–	0.2
August 17	100		0.80	0.27	0.3	0.1	0	0.2
August 20	200		0.80	0.19	0.3	0.2	0	0.2
September 13	1,000		0.63	0.18	0.2	Faint traces	0	0.1*
September 14			0.65	0.18	0.1*	0.0	0	0.1
September 15	800		0.67	0.09	0.1*	0.0	0	0.1
September 16	800		0.68	0.29	0.1*	0.0	0	0.1*
September 17	700		0.68	0.18				0.1–
September 18	700		0.66	0.09				0.1–
September 19	700		0.64	0.09				0.1–
September 20	600		0.68	0.10				0.1
September 21			0.60	0.12				0.1
September 22	600		0.65	0.18				0.1
September 23	500	Influent to mixing basin	0.65	0.16				0.1
September 24	500		0.68	0.12				0.1
September 25	400		0.62	0.18				0.1
September 26			0.62	0.18				0.1
September 27			0.75	0.30				0.1*
September 28	200		0.60	0.20				0.1*
September 29	200		0.68	0.16				0.1*
September 30	200		0.67	0.19				0.1–
October 1	150		0.66	0.32				0.1*
October 2	150		0.62	0.09	0.1*	Faint traces	0	0.2
October 3	150		0.65	0.13				0.1–
October 4	150		0.61	0.09				0.1–
October 5			0.60	0.12				0.1–
October 6	180		0.66	0.09	0.1*	Faint traces	0	0.1*
October 7	180		0.61	0.10			0	0.1

dissolved oxygen samples ranged from zero at the bottom to 6.5 at the top.

We received a few complaints of tastes and odors during the summer. These complaints came at a time when the water was lowest, and the dissolved oxygen approximately zero at the point of intake. This was the condition of the water each time the Coca-Cola Company complained of tastes.

The lake was not treated during the summer because the only trouble that amounted to very much was that of the cyclops' appearance at the plant, and we were not successful in finding a dosage that would destroy them. So far we have not found a dosage of

TABLE 2

Method of treating filters

DATE (1930)	CHEMICAL USED	POINT OF APPLICATION	DOSAGE	HOURS: Dosing	HOURS: Stand after dosing	HOW APPLIED	RESULTS	REMARKS
April 29........	Copper sulphate	In filter	Conc. sol.	0.5	12	Tow bag method	No good	Walls sprayed
May 1..........	Chlorine	Influent to filters	1.20 p.p.m	1.0	16	Chlorinator	Slight	Cyclops missing one day
September 24...	Copper sulphate	In filter	Conc. sol.	0.5	4	Tow bag method	No good	
October 3.......	Chlorine	Influent to filters	1.80 p.p.m.	1.5	2	Chlorinator	No good	
October 6.......	Chlorine	" "	1.50 p.p.m.	1.0	2	Chlorinator	Fair	Cyclops survived

copper sulphate or chlorine that will kill cyclops, although we have used chlorine dosage from 0.3 to 0.8 p.p.m., the maximum capacity of our machine, and a concentrated solution of copper sulphate on the filters.

Dr. Frank E. Hale, of New York, read a paper before the February meeting of the New England Water Works Association at Boston, giving from 1.0 to 3.0 p.p.m. as the necessary dosage for treatment of cyclops and daphnia. This information was received too late to be tried out before this Convention. Besides the capacity of our chlorine machine is too small.

In conclusion, we should state that we have had unlimited numbers of cyclops from the first of April to the present time.

WATER WITCHING[1]

By H. V. Pedersen[2]

The art of locating underground streams of water by means of a witch stick is probably as old as any form of witchcraft practiced by the people of the middle ages. I know of no records which will show how extensively this art was practiced by our forefathers, but one thing is certain, that, if it ever was practiced extensively, it died with the rest of the beliefs in witchcraft as the human race became more enlightened.

It would be interesting to know just how the term "Water Witch" came to be applied to a person who could take a forked green twig and have it act rather peculiar when it came directly over an underground stream of water. The largest Webster's Dictionary made defines a "Water Witch" as a small water bug of some sort, but does not mention it in connection with locating underground streams of water. The term seems to have no place in the English language. It is ignored completely by modern science and is scoffed at by the engineering profession and well drillers. But in spite of this low rating and the general unbelief in them, the "Water Witch" still exists and from recent experiences I am rather inclined to believe there may be more to this art than has been attributed to it.

When I was a youngster some four or five years old my folks moved to an acreage in the outskirts of the city of Des Moines, a distance, at that time, of a mile from the nearest city water mains. The very first thing my father did was to dig a well to secure a water supply. A shallow well located in one corner of the acreage where the elevation of the ground was considerable lower than the rest of the place brought forth a meager supply of water. Several other attempts at different locations also proved failures. When it looked as if the fond hopes of my parents were going to be shattered from the failure to obtain an adequate supply of water along came a "Water Witch" who said he could locate water.

[1] Presented before the Missouri Valley Section meeting, November 6, 1930.

[2] Superintendent, Water Works, Marshalltown, Ia.

I can hazily remember him taking a willow forked twig and walking up and down the hillside of our new home site and telling my father to dig at a certain spot in a mysterious sort of way. I do not know how much faith my father had in the witch stick, but, nevertheless, excavation was commenced on the designated place. At a depth of 80 feet a vein of water was encountered which proved to be very prolific and which furnished the family with an excellent quality of water for many years.

On the face of it there is nothing very strange or interesting about this story. The same thing might have happened to any one in hundreds of other places. The fact that water was obtained at the time the well was dug meant nothing to me as a child. It was not until later, after I had heard the story repeated over and over, that I realized the well was located on the very highest top of the hill. This, of course, in itself is not sufficient proof of the powers of the "Water Witch" as many wells have been located on tops of hills. The thing that caused a profound impression, upon me since early boyhood was the fact that the well on my father's acreage proved to be the only successful well for many blocks around. Each new family, as they moved to the neighboring acreages, tried to obtain a well, but up until the advent of the city water my father's well reigned supreme and was the chief source of water for many thirsty mouths.

It was probably because of my early impression that I permitted the recommendation of a "Water Witch" to influence me this fall in locating a new well for the city of Marshalltown. The extremely dry spell this last summer taxed the water supply of Marshalltown to the limit. Rather than wait for a serious shortage an effort was made to secure an additional supply. We had two underground sources available and it resolved itself into a question which of the two would be the most economical to develop. We knew from past experience that a shallow sand underlies a large portion of the water works property varying in depth from 30 to 50 feet below the surface of the ground. Some forty years ago several 6-inch sand points driven down into this shallow sand deposit furnished an adequate supply. As the city grew in population and a larger supply was needed, additional well points were driven until there were about sixty in number. These well points were spaced 50 feet center to center, in regular straight rows and were all connected to a common suction pipe.

When the requirements of the city increased beyond the shallow well system just described a deeper well was drilled to see what could be found. At a depth of 150 feet a water bearing sand was discovered which produced 300 gallons per minute. As it became necessary to drill new wells, due to the rusting out of the shallow well casings, the well points were gradually abandoned for the deeper wells. At the present time nine deep wells and five shallow wells have been supplying on the average of two and one-half million gallons per day. Due to the drouth this summer the average pumpage increased to three and one-quarter million gallons per day and the well system showed signs of weakening.

It was apparent that, if there was an adequate quantity of water in the shallow sand deposits, it could be developed much more cheaply than additional deep wells. In studying the problem I came to the conclusion that there must be a goodly quantity of water in the shallow sand if a better way of developing it could be worked out. I finally decided to sink a gravel packed well into the shallow sand deposit to settle the argument. After this decision was reached the next problem was where to locate the new experimental well. One place on an approximately ten acre tract looked as good as another and as far as the eye was concerned there was little choice. It then occurred to me that it would do no harm to let a "Water Witch" whom I had become friendly with, do his stuff. A survey was immediately begun with a result that the "Water Witch" recommended a place where he claimed an underground stream flowed. As one place was as good as another I decided to sink a test hole. The test hole proved so satisfactory that I decided to locate the new gravel packed well on the spot recommended by the "Water Witch."

The gravel packed well was constructed by first sinking a 40-inch steel casing down through the sand deposit. Then 20 feet of 16-inch brass strainers were set in place in the center of the hole and then pea gravel was packed around it. The final step consisted of removing the 40-inch steel casing. The total depth of the well is 46 feet and the water stands within 14 feet of the surface of the ground. As soon as the well was ready it was tested for capacity.

When I first considered sinking a shallow gravel packed well I had expressed the opinion that a well which would produce 500 gallons per minute would be considered quite satisfactory. The test consisted of pumping the well for thirty-six hours with a turbine type pump driven with a gasoline motor. When pumping at the rate

of 750 gallons per minute the draw-down in the well was 4½ feet. When pumping at the rate of 1800 gallons per minute the draw-down was 14 feet. This test satisfied me that we had obtained a much better well than my fondest expectations.

Of course, it is possible that we might have accidentally located a well on a vein of water without the aid of a "Water Witch." The possibility of such luck can be determined to some extent by considering that out of the 60 shallow sand points stationed at regular measured intervals in straight rows, only one point came anywhere near either the main vein or one of its lesser tributaries. After tracing the main underground stream back for a quarter of a mile it could easily be seen why two-thirds of the sand points produced but very little water.

Mr. Tom Townsend who performed the stunt of witching explains the phenomenon of the witch stick as a completing of an electrical circuit. He takes a green willow forked twig and breaks the two ends until they dangle by mere threads. He grasps the dangling ends, one in each hand, holding one hand directly above the other and points the fork straight out perpendicular with his body. As Mr. Townsend crosses a flowing stream of water the stick turns in the direction of the flow. It sounds fishy, but nevertheless it seems to work and work accurately. Just what a scientific explanation of this phenomenon would sound like is only a matter of speculation, but I would assume that it would deal with frequency and wave lengths. That a complete circuit is established at the moment the forked stick crosses the flowing stream of water is apparent. But whatever the explanation I am of a firm opinion that a true "Witch" can locate underground streams of water. One thing more is true, that the witch stunt will not work for everyone and that those who can work it are endowed with a peculiar gift which when put to proper use can prove a blessing to mankind.

REPORT OF THE TREASURER, DECEMBER 31, 1929, TO AND INCLUDING DECEMBER 31, 1930

The Treasurer's report as of December 31, 1929, showed the following balances:

Bank balance after deducting outstanding checks...	$2,555.54	
Interest due on permanent investments, certificates of deposit and bankers acceptances..........	7,272.07	
Investments in permanent fund......................	14,000.00	
Total, which excludes balance credited to Electrolysis fund, amounting to $925.11..............		$23,827.61

The corresponding figures on December 31, 1930, are as follows:

Unencumbered bank balance December 31, 1930....		$4,668.78	
Estimated interest on permanent investments due but not deposited..........................		45.00	
Investments in permanent fund:			
Dominion of Canada, 5 percent..............	$4,000		
4th Liberty Loan, $4\frac{1}{4}$ percent..............	2,000		
Province of Ontario, 5 percent.............	3,000		
Province of British Columbia, $4\frac{1}{2}$ percent.	1,000		
Alabama Power & Light Co., $4\frac{1}{2}$ percent..	2,000		
Chesapeake & Ohio Ry. Co., $4\frac{1}{2}$ percent..	2,000		
N. American Edison Co., 5 percent........	2,000		
N. Y. Steam Corp., 5 percent.............	2,000		
Int. Tel. & Tel. Corp., 5 percent..........	3,000		
So. Pacific Ry., $4\frac{1}{2}$ percent............	5,000		
Total..................................		26,000.00	
		$30,713.78	
Deduction to be made for Electrolysis Fund....		976.78	
Total, excluding Electrolysis Fund............			$29,737.00
Increase during 1930.........................			$5,909.39

A summary of the transactions of the treasurer from December 31, 1929 to December 31, 1930, is as follows:

December 31, 1929—Balance in bank		$7,456.28	
Receipts from secretary, interest credited by bank on daily balance and interest from investments:			
January	$20,000.79		
February	7,543.30		
March	7,456.54		
April	13,103.34		
May	5,645.67		
June	10,962.25		
July	2,737.04		
August	4,624.61		
September	3,224.30		
October	4,505.81		
November	3,773.97		
December	3,014.46		
Total		86,592.08	
Disbursements, as shown by checks paid and other charges made by the bank:			
January	$4,763.74		
February	20,631.21		
March	4,881.53		
April	9,916.08		
May	12,336.01		
June	5,775.38		
July	7,567.93		
August	3,220.60		
September	4,919.85		
October	2,776.52		
November	6,533.48		
December	4,999.67		
Total		88,322.00	
Excess of disbursements over receipts		$1,729.92	$1,729.92
Bank balance as of December 31, 1929			7,456.28
Difference, which is the same as the bank balance reported for December 31, 1930			$5,726.36
Checks outstanding December 31, 1929:			
No. 4349	$35.00		
No. 4356	6.86		
No. 4357	6.72		
No. 4359	500.00		
No. 4361	250.00		
No. 4364	250.00		
No. 4365	9.00		
Total		$1,057.58	

The investments in the permanent fund as of December 31, 1929 and December 31, 1930, were as follows:

Description	Face Value: As held December 31, 1929	Face Value: As held December 31, 1930
Dominion of Canada, 5 percent	$4,000	$4,000
4th U. S. Liberty, 4¼ percent	2,000	2,000
Province of Ontario, 5 percent	3,000	3,000
Alabama Power & Light Co., 4½ percent	2,000	2,000
Province of British Columbia, 4½ percent	1,000	1,000
U. S. Treasury Certificates, 5⅛ percent	2,000	
Chesapeake & Ohio Ry. Co., 4½ percent		2,000
N. American Edison Co., 5 percent		2,000
N. Y. Steam Corp., 5 percent		2,000
Int. Tel. & Tel. Corp., 5 percent		3,000
So. Pacific Ry., 4½ percent		5,000
Total	$14,000	$26,000

WM. W. BRUSH,
Treasurer.

DISCUSSION

Treating Highly Turbid Waters

The purification works of the St. Louis and Kansas City plants are quite similar and the difficulties encountered in operation are so similar that they might well be called twins. The difficulties encountered with the tangential mixers have been covered so thoroughly by Mr. Fleming[1] and conform so uniformly with our experience that a discussion seems unnecessary.

Our experience with mechanical clarifiers has not been as gratifying as the results at St. Louis. While the same type mechanism is used in both places, the structures in which they operate are very dissimilar. At Kansas City, we have four circular preliminary settling basins, 200 feet in diameter, with a capacity of 4 million gallons each. This represents a retention of four hours at rated capacity. The sludge is removed by gravity through a manifold of various sized orifices. If an attempt is made to carry this sludge at a greater concentration than 15 percent solids, we invariably get stratification in the basin; and sludge with as low as 6000 p.p.m. turbidity builds up and soon sweeps over the outlet weir. The percent removal has been satisfactory. If we eliminate the three months in which the suspended solids in the raw water were below 500 p.p.m., we find an average removal for the remaining nine months of the year ending April 30th of 85.4 percent. During the past winter changes were made in the sludge line which make the percent of waste water used for the year an unfair figure, but for April of this year 4.26 percent of the raw pumpage was used to remove 2244 p.p.m. suspended solids. This gives a water waste of 1.9 percent for each 1000 p.p.m. suspended solids removed, which is certainly out of line with Mr. Fleming's figure of one-half of 1 percent. The fact that April is a month in which we encounter relatively finely divided suspended matter may account to some extent for this excessive use, and a record of the results over the entire summer may show a much closer approach to the water economy shown at St. Louis.

The Missouri river water at Kansas City coagulates very readily

[1] Journal, December, 1930, page 1559.

most of the year. Where softening is not included, very small doses of coagulants can be used. For the year ending April 30, 1930, the average dose at Kansas City was 173 pounds of alum and 82 pounds of lime per million gallons of water treated. The water treated carried an average of 400 p.p.m. suspended solids.

The sludge in the coagulating basins maintains a density of about 100,000 turbidity, and we have found that if we allow it to build up more than 5 feet in the 17-foot basin, the basin's efficiency certainly is affected. The sludge from the coagulating basins is removed by gravity through a throttled sludge line. The removal is continuous during periods of high turbidity, and intermittent in periods of low turbidity. The bottoms of the coagulating basins are cut up in shallow hoppers 100 feet square with a 4 percent slope to the drain in the center. Due to the very slight slope to these hoppers, the suspended solids that have dropped out of suspension are very little affected by opening the plug valves. Soundings are taken of the mud depth in these basins at regular intervals and when it reaches a depth of 4 feet, that flushing will not move, the basin is cut out and washed. Soundings taken in the basin around the plug valve reveal that the angle of repose of this material is such that a 4 percent slope becomes simply a gesture as far as a hopper effect is obtained.

We have rather reluctantly accepted the fact at our new filter plant that the most economic turbidity to apply to the filters is 40 p.p.m. This is a radical departure from our preconceived ideas of plant operation, but the results obtained during the past year seem to definitely establish this fact. The average turbidity of the applied water was 36 p.p.m. Gravimetrically the suspended solids were 24 p.p.m. An average of 107 pounds of suspended solids were removed per square foot of filter area. This in turn was washed from the filters with 1.38 percent of the filtered water. The filter wash rate is a 24-inch rise per minute. The filter beds have remained in very good condition, with no appreciable coating of the sand grains or accumulation of mud balls.

George F. Gilkison.[2]

[2] Superintendent of Filtration, Water Department, Kansas City, Mo.

EDITORIAL COMMENT

THE MODERN DOWSER

Witchcraft in the water supply business is always as interesting as in any other enterprise. When the accomplishments of a "water witch" obtain the grateful comment accorded him by Mr. H. V. Pedersen[1] in his paper in this issue on "Water Witching," it brings to mind once more the question of the use of the divining rod for locating underground waters. Although this use has been dismissed by latter day scientists as paralleling any other form of charlatanism, yet to-day the practice in this art and its underlying principles are the subject of as much discussion as one hundred years ago.

Most scientific reports, of which there have been a number, place little credence in the efficacy of the use of the divining rod in locating subterranean supplies of water and metals and, although the subject seems to have been dismissed by a number of investigators in past years, it is still one of absorbing interest in almost every country in the world. The observations reported by Mr. Pedersen are as inconclusive as those usually reported by other observers. Mr. Pedersen's conclusion in his article: "It sounds fishy, but nevertheless it seems to work and work accurately," is matched by the comment reported to have been made by Sir Herbert Maxwell[2] who once remarked, "I don't believe in the divining rod but I don't deny that its virtues are genuine; and were I in straits to find water, I should employ without hesitation a professional water finder—rod and all—if there remains one so successful as Mullins was."

In reviewing the literature on this form of investigation for underground waters, it is surprising to note how frequently the investigating commissions end up with the dismissal of the topic and yet refer to the interesting, unexplained phases of dowsing, for which they have no satisfactory hypotheses.

The recent discussion by C. A. Browne, already referred to herein,

[1] This JOURNAL, page 586.

[2] Quoted by C. A. Browne, Observations Upon the Use of the Divining Rod in Germany, Science, January 23, 1931, p. 84.

is, therefore, well worth reading in the light of his own observations recently in Germany. For those who wish to combine the operation of water works with "alchemy, astrology, table-tipping and other occult sciences"[2] the following texts should be of interest:

1. J. W. Gregory, Water Divining, British Water Works Association, 1927; Reprinted in Annual Report of the Smithsonian Institution, 1928, p. 325.
2. Barrett and Besterman, The Divining Rod.
3. R. Janota, Bulletin of the Czecho-Slovakian Academy of Agriculture, Vol. VI, No. 2, pp. 190–197, with report of discussion, ibid., pp. 198–202. See also abstract, Internat. Review of Agriculture, Monthly Bulletin of Agricultural Science, May, 1930, p. 162.
4. Henry de France, The Modern Dowser. G. Bell and Sons, London.

Abel Wolman.[3]

[3] Editor-in-Chief, the Journal of the American Water Works Association; Chief Engineer, Maryland State Department of Health, Baltimore, Maryland.

SOCIETY AFFAIRS

KENTUCKY-TENNESSEE SECTION

The sixth annual meeting of the Kentucky-Tennessee Section was called to order at 10 a.m., Thursday, February 5, 1931, at the Noel Hotel, Nashville, Tennessee, by A. E. Clark, Chairman. The attendance was approximately one hundred and twenty-five. The address of welcome was given by the Hon. Hilary E. Howse, Mayor of Nashville, Tennessee. Response was given by W. S. Patton, Manager of the Ashland Waterworks, Ashland, Kentucky. The remainder of the morning session was devoted to addresses by Dr. E. L. Bishop, State Health Commissioner of Tennessee; G. H. Fenkell, President of the American Water Works Association; and Beekman C. Little, Secretary of the American Water Works Association.

At the afternoon session the following papers were given:

"Stream Flow Records and Their Relations to Public Water Supplies," Warren R. King, District Engineer, U. S. Geological Survey, Chattanooga, Tenn.

"Methods of Cleaning Filter Sand," C. V. Swearinger, Chemist, City Water Company, Chattanooga, Tenn.

"Comparison of Chemical and Hydraulic Methods of Cleaning Filter Sand as Tried at the Filtration Plant at Nashville, Tenn.," Herbert A. Guy, Chief Chemist and Superintendent, Filtration Plant, Nashville, Tenn.

"The New Water Supply Unit at Dyersburg," S. R. Blakeman, Superintendent, City Water and Light Departments, Dyersburg, Tenn.

The election of officers resulted in Mr. H. K. Bell, Consulting Engineer, Lexington, Kentucky, being selected as Chairman for the coming year; Mr. James Sheahan, General Manager, Memphis Water Works, Memphis, Tennessee, Vice-chairman; Mr. Felix Vannoy, Superintendent of Water Works, Madisonville, Kentucky, and Mr. G. B. Shawver, Superintendent Plant Construction and Operation, Tennessee Electric Power Co., Chattanooga, Tennessee, as Trustees. They re-elected Mr. F. C. Dugan, Chief Engineer, State Board

of Health of Kentucky, Louisville, Kentucky, as Secretary and Treasurer.

In the evening the Committee on Entertainment arranged for a smoker, given through the courtesy of a number of Nashville firms.

The session Friday morning was devoted to the following papers and their discussions:

"Distribution," H. C. Bristol, Superintendent, Water Department, Alcoa, Tenn.

"Valuation and Rates as Applied to Water Utilities," Malcolm R. Williams, Engineer, Tennessee Railroad Public Utilities Commission, Nashville, Tenn.

"Meter Rates as Compared to Flat Rates as a Revenue Producer," G. B. Shawver, Superintendent Plant Construction and Operation, Tennessee Electric Power Company, Chattanooga, Tenn.

"Emergency Water Supply Unit for Lexington from the Kentucky River," Grant Bell and Clark Cramer, Engineers, Lexington Water Co., Lexington, Ky.

The afternoon session was devoted to the following papers and a general discussion of problems met in the two states resulting from the unprecedented drought:

"The Drouth and Peak Loads," W. H. Lovejoy, Superintendent of Filtration, Louisville Water Company, Louisville, Ky.

"Water Shortage in Kentucky Cities Due to Drouth Conditions," R. R. Harris, Assistant Engineer, State Board of Health, Louisville, Ky.

A dinner dance was held in the evening.

The Saturday morning session was devoted to the reading of the paper "Ammonia-Chlorine Process for Taste and Odor Elimination," by A. E. Clark, Tennessee State Health Department, which was followed by a general discussion of the subject of taste and odor elimination.

A paper on the "Facts Concerning the Origin and Evolution of the Nashville Waterworks" was given by R. L. Lawrence, Jr., of the Waterworks Department. This paper was amplified by a very interesting discussion by Captain George C. Reyer, Superintentent, Water Works Department.

The meeting adjourned to the new filtration plant, where a lunch was served.

F. C. Dugan,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Protecting Water Pipes Against Corrosion. The National Tube Co. Cont. Rec. and Eng. Rev., 43: 1433–6 and 1442, 1929. An extensive discussion of water pipe corrosion, particularly external corrosion, its causes, and its prevention by means of applied coatings. Uniformity of the pipe metal and surface finish are important. The composition of the metal seems to have little effect. Various coatings are discussed and the methods of applying them described. Coal tar pitch, when properly refined, makes one of the best preservatives dips but the range between the brittle and melting points rarely exceeds 45°F. Asphalt mixtures are available that have a temperature range of 120–130°F. The absorption of solar energy may be limited considerably by dusting with cement or white sand, or by whitewashing. Encasing in concrete is an effective protection against corrosion, but not against stray current electrolysis.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Reliable Pipe for Main Arteries in Large Cities Needed. Charles B. Burdick. Eng. News-Rec., 103: 922, December 12, 1929. Cast iron pipe has been employed in distribution systems for more than 50 years. This experience, coupled with the use of this pipe in isolated cases over periods longer then 2 centuries, testifies to its great durability under ordinary circumstances. Nothing better has been found for connecting the street pipes than the lead-and-yarn joint. The greatest need at the present time, so far as the distribution network is concerned, is an interior pipe surface which will prevent tuberculation. The customary coal tar coating, while apparently useful, leaves much to be desired. It is very desirable that some material be used for the pipe shell less likely than cast iron suddenly to open up large apertures in cases of failure. The use of steel pipe with shell sufficiently thick to prevent serious impairment of strength from moderate surface corrosion seems warranted in some cases. When making financial comparison of pipes known to be capable of reasonably reliable service, it is customary and proper not only to compare

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

the initial investments, but also to consider further allowances to cover repairs, depreciation, leakage, and prospective damages from failures.—*R. E. Thompson.*

Earlier Conclusions on Value of *C* for Various Materials after Use Confirmed. Dabney H. Maury. Eng. News-Rec., 103: 923–5, December 12, 1929. No satisfactory bituminous or asphaltic dip has been developed which will protect the internal surface of cast iron, steel, or wrought iron against tuberculation or external pitting, even when applied in conjunction with a wrapping of felt or burlap. Wrapped steel mains in Butte, Mont., were found to be seriously damaged by electrolysis. The author has never seen an instance of rupture caused by internal pressure in a sound cast iron main, and he believes that breaks are often caused by settlement due to joint leaks. Unequal support of the pipe throughout its length is another factor. The author's experience since his paper on large supply mains was published in 1924 (this Journal 12: 1) would appear to justify a value of *C* in the Hazen-Williams formula of at least 140 for reinforced-concrete pipe well spaded against smooth steel forms, and of 130 for well-built redwood-stave pipe. Data are given on the coefficients of several pipe lines. The value of *C* in one cast iron line decreased from 130–140 to 70 after 17 years service, increased to 110 after cleaning, and dropped again to 70 after 7 years additional service. Other lines carrying different types of water maintain their carrying capacity for a number of years. There is a new type of pipe on the market which merits careful consideration. In the manufacture of this pipe, which was invented in France, a shell of concrete reinforced with steel is first made by the centrifugal process and before the concrete is set, carefully graded stones, or fragments of coke or hard-burned clay, are partially embedded in the shell by centrifugal action. These fragments afford a rough surface for a lining of asphalt one-half inch in thickness which is later applied by centrifugal force. It is claimed that this pipe has a high coefficient *C*. The Asphalto-Concrete Corporation is the American licensee of the French patents.—*R. E. Thompson.*

A New Fitting for Welded Pipe. E. G. Luening. Ind. Eng. Chem., News Ed., 7: 14, 3–4, 1929. From Chem. Abst, 23: 4174, September 10, 1929.—*R. E. Thompson.*

One Firm's Practice as to Choice of Materials for Pipe over 30 Inches Diameter. D. W. Howes. Eng. News-Rec., 103: 923, December 12, 1929. Data are given on the practice of the firm of Fuller and McClintock regarding large mains. For mains 30 inches or less in diameter, cast iron is almost invariably employed, as other materials are scarcely competitive as to cost and durability. For sizes 30 to 42 inches, competitive bids are asked on cast iron, steel, and concrete; for larger sizes, cast iron is usually eliminated on account of the increased danger of breakage. Each case must be considered on its merits. The thickness of steel required is estimated from the load to be withstood and $\frac{1}{16}$-inch is added for corrosion, the minimum thicknesses employed being: for less than 48-inch diameter, $\frac{3}{8}$-inch; for 48 to 72-inch, $\frac{7}{16}$-inch; and for larger sizes, $\frac{1}{2}$-inch or more. Cleaning the plate by pickling gives an excellent surface, but

all trace of acid and alkali must be subsequently removed. If this cannot be guaranteed, reliance is usually placed on wire brushing. Sand blasting gives very good results, but is extremely expensive. Application of protective coating to steel pipe by dipping is favored, using an asphalt base compound. External wrapping is believed to be justified.—*R. E. Thompson.*

Steel Chosen for 54-inch Water Intake at East Chicago. PAUL HANSEN. Eng. News-Rec., 103: 922, December 12, 1929. The relative merits of reinforced concrete, cast iron, and steel were reviewed carefully and steel finally chosen as the most suitable and economical material for a new intake which is being designed for East Chicago, Ind. Alternative bids are being secured on ½- and ⅝-inch thicknesses of steel and Armco iron and on 4 types of joints.—*R. E. Thompson.*

Transmission of Water Under Pressure. FRANK E. WINSOR. Eng. News-Rec., 103: 925–6, 1929. A brief general discussion of the selection of pipe for water distribution systems.—*R. E. Thompson (Courtesy Chem. Abst.).*

Observations on Cast Iron, Steel, and Reinforced Concrete Pipe. ALEXANDER POTTER. Eng. News-Rec., 103: 925, December 12, 1929. Brief discussion of the selection of materials. The majority of concrete pipe manufacturers think they can produce by their own methods better and stronger concrete than if they were to follow the specifications of the purchaser. To avoid disputes of this nature, only the length of curing, pressure and leakage test, and form of joint should be specified. The importance of sealing the joints of cast iron pipe on the inside was demonstrated by inspection of parallel lines of 60- and 48-inch pipe, the former having been laid 19 years and the latter, 15 years. All the joints of the 60-inch line were pointed with a rich mixture of sand and cement, while those of the 48-inch line were not. The interior of the former showed very little growth; while in the latter, growths were quite pronounced, extending in both directions from the joints. The author believes that more than 90 percent of breaks are caused by improper grading of the trench bottom and faulty backfilling. Shovels, or ordinary tampers, do not give satisfactory results, offset tamps as used on railroads being better. Instance cited of leakage of cast iron pipe line with Hydrotite joints dropping from a considerable amount to a reasonable figure in 24 days.—*R. E. Thompson.*

Always a User of Cast Iron Pipe. Some Causes of Breaks. ROBERT E. HORTON. Eng. News-Rec., 103: 926–7, December 12, 1929. The author believes that breaks in large cast iron pipes are often the direct result of the pipe becoming bell-hung owing to inadequate blocking or tamping. Leadite or similar compound will make a reasonably tight and very satisfactory joint for cast iron pipe at a cost materially less than that of lead joints. One disadvantage is that the joint, even if a good one, will often show considerable leakage at first. This necessitates leaving the trench open for a week or two, in the case of large pipe, for the joint to set up to its normal degree of watertightness. The importance of accuracy in length, form, and alignment of cast iron pipe, particularly for use in crowded situations, is emphasized. A break

occurred in a 36-inch cast iron force main in Albany on July 31, 1929. During the laying of this line difficulty was experienced in alignment owing to the ends of pipe not being in parallel planes.—*R. E. Thompson.*

High Rockfill Dam Designed with Jointed Concrete Face. I. C. Steele. Eng. News-Rec., 104: 92–5, January 16, 1930. The Salt Springs dam is a rockfill structure now being built by the Pacific Gas and Electric Co., to impound 130,000 acre-feet of water on the Mokelumne River in California for power development. Owing to the unusual height for a dam of this type, 300 feet above streambed and 328 feet above lowest foundation, great care was exercised in determining side slopes and in selection of materials and methods of construction. The inaccessibility of the site and the ample supply of granite rock available determined the type of dam. The concrete facing is being laid in panels 60 feet square with the joints supported on concrete ribs in the placed rock section. The alignment of this upstream face forms a warped surface designed to provide maximum protection against cracking when settlement of the fill occurs. The slope of the downstream face will be 1.4 to 1 vertical and of the upstream slope 1.3 to 1. The top width will be 15 feet and the base width approximately 900 feet (maximum). The length of the crest will be 1300 feet and the total volume of the structure approximately 3,000,000 cubic yards. The stream was bypassed through a 19-foot internal diameter tunnel driven through solid granite which will later be used as a permanent outlet. The total length is about 1100 feet, of which distance approximately 900 feet is lined with unreinforced concrete with average thickness of 18 inches. A period of 60 days was allowed for shrinkage of the lining, after which grout was applied under pressure of 100 pounds per square inch.—*R. E. Thompson.*

Calderwood High Arch Dam Designed with Deep Cushion Pool to Receive Overflow. Eng. News-Rec., 103: 954–8, December 19, 1929. A thin-section concrete-arch overflow dam, 230 feet high above lowest foundation, with radius at the crest of 312.5 feet, is being built at Calderwood, Tenn., as the third unit of the hydro-electric development of the Little Tennessee River by the Aluminum Co. of America. In addition to a cushion pool formed by a concrete gravity ogee-section dam, with a crest length of 390 feet, the downstream toe is protected by reinforced-concrete armor of 3 feet minimum thickness and concrete bucket deflectors. Elaborate preparations are being made to determine the arch deflection as the reservoir fills. The pressure tunnel is 26 by 24 feet inside the concrete lining and 2400 feet long. The minimum thickness of the lining is 12 inches.—*R. E. Thompson.*

Circular Cell Cofferdam on Deadman Island Dam. William H. Fowler. Eng. News-Rec., 104: 66–8, January 9, 1930. A circular cell cofferdam of the same type as that used in raising the U. S. battleship "Maine," consisting of 78 units, 40 feet in diameter, built of 40-foot sheet-steel piling, was used in constructing the Deadman Island dam on the Ohio River at Shields, Pa. The project is part of the government's 9-foot waterway development of the Ohio River. The dam, of overflow type with ogee section, is 1585 feet long between abutment and outer face of lock structure. Resting on solid rock bottom,

dam is about 38 feet high with vertical upstream face, crest width of 4½ feet, and base width of 60 feet. The cofferdam was built in 5 rectangular sections, each section inclosing an area 80 feet wide and varying in length from 210 to 498 feet. The cofferdam cylinders were driven to rock and filled with sand and gravel to the top. Adjacent cells were placed 2 feet apart, each gap being closed with 2 curved sheet pile diaphragms and connected by means of T-piles to the walls of the cells. All pockets of the cofferdam were filled and banked on the outside with materials dredged from the river with clamshells, but no banking was used on the inside. The cofferdam proved to be remarkably tight.—*R. E. Thompson.*

Method for Rapid Setting of Form Points on Small Arch Dam. James Girand, Jr. Eng. News-Rec., 104: 36–7, January 2, 1930. A brief description of rapid method employed for setting points for the form-work during construction of a small arch dam at Safford, Arizona. The dam is of the variable radius type, 120 feet high.—*R. E. Thompson.*

Reconstruction of Table Rock Cove Earth Dam after Dangerous Washout and Slump. S. T. Henry. Eng. News-Rec., 103: 934–7, December 12, 1929. On May 4, 1928, the Table Rock Cove dam of the Greenville, S. C., water supply system, containing about 600,000 cubic yards of earth, was nearly lost by a washout on the downstream face due to the failure of a 42-inch Class D cast iron drainage pipe passing through it in a trench along the bank of the stream. The embankment is across a narrow valley and has a crest height of 140 feet above the bed of the stream. The pipe, in 12-foot lengths, was placed to bypass the stream during construction and to drain the reservoir as required, and was laid in a trench excavated for the most part in rock. Concrete cutoff walls, 18 inches thick, were built across trench and surrounding the pipe, 40 to 95 feet and averaging 55 feet apart. Between the cutoff walls the trench was backfilled with earth tamped around the pipe. One valve was placed at the downstream end of the pipe, the upstream end being without any regulating device. Shortly prior to the accident heavy precipitation had raised the level of the pond to within 15 feet of the spillway crest, or 25 feet below the dam crest. The failure occurred suddenly in the shape of a blowout near the toe of the downstream face of the dam a short distance above the valve chamber. For a distance of more than 150 feet the water from a break in the pipe cut a deep narrow trench in the embankment. The main break was about 160 feet upstream from the lower end of the pipeline. Detailed inspection following the failure showed that the pipe had been damaged for a considerable distance. In the repair of the structure a portion of the pipe was removed and the remainder plugged with concrete and filled with carefully-selected, puddled clay. A fill of loose rock was placed across the valley to form the toe of the new earthfill and clay core. The coarse material seal over the core has very flat slopes on its face, giving a much greater section than the original embankment. The total amount of material placed in closing the break was about 280,000 cubic yards, compared with the estimated loss of 60,000 cubic yards from the washout. Water has now been standing 15 feet below the spillway crest, or higher, for nearly 6 months.—*R. E. Thompson.*

Dam Design Provides for Deflection by Horizontal Hinge Joint. D. C. Henny. Eng. News-Rec., **104**: 284–6, February 13, 1930. The water supply of Ashland, Ore., (population 6,000) is obtained from Ashland Creek, which originates in a steep mountain range. The flow varies from about 100 second-feet in maximum flood to an average of about 5 second-feet in summer and about 3 second-feet in extremely dry seasons. Lawn sprinkling and orchard irrigation produce a summer peak demand of approximately 380 gallons per capita per day, equivalent to a flow of about 3.5 second-feet. Prior rights to creek water amount to about 2 second-feet. A dam constructed recently, creating 800 acre feet of storage, will provide for a 50 percent increase in population at the existing rate of use. The dam is located in a federal forest reserve about 3 miles from the city and the drainage area is closed to the public. The structure is a variable-radius arch, 112 feet high and 465 feet long on the crest. To relieve excess shear and tension stresses in the arch, reinforcing steel amounting to 0.05 percent of the total volume of the dam was distributed near the faces, in addition to providing a horizontal joint in the base of the upstream face. Vertical construction joints were grouted about 3 months after completion of the structure. After slowly filling during the past summer, the measured deflection was found to be about one-half the calculated amount, with no leakage or cracks in evidence.—*R. E. Thompson.*

Four Steel Dams—Their Design and History. J. F. Jackson. Eng. News-Rec., **104**: 281, February 13, 1930. The Redbridge steel dam, near the shore of Lake Superior in Houghton County, Michigan, was built in 1900 and is still in good condition. The structure is 480 feet in length and 75 feet in height at its center portion. The first steel dam of this type was built at Ash Fork, Arizona. A third was built on the Missouri River near Helena, Mont., but failed a year later due to defective foundations. Advantages of this type of construction are: (1) watertight as a boiler; (2) no fear of settlement or distortion cracks; (3) a general factor of safety of 4 or more as desired; (4) ease of obtaining factor of safety against sliding at least twice that usually obtained in masonry or concrete structures; (5) no uncertainty about hydrostatic uplift; (6) long life and easy inspection. Bibliography appended.—*R. E. Thompson.*

Irrigation Works Construction in Mexico. R. M. Conner and Andrew Weiss. Eng. News-Rec., **104**: 101–4, January 16, 1930. An illustrated description of the Nueva España project, about 60 miles west of Laredo, on the international border. A storage reservoir will be created on the Salado River by the construction of the Don Martin dam, which consists of an earth embankment 3484 feet long with a maximum height of 105 feet and an effective concrete spillway length of 565 feet. Latter consists of an extension of the dam and is fitted with regulating gates. There is also an earth dike about 6 miles long and having maximum height of 32 feet to close low-level openings between the hills which surround the reservoir. The fill is a mixture of earth and gravel. A reinforced-concrete slab, 11 inches thick at its connection with the upstream cutoff wall and 8 inches where it joins the parapet wall, is being laid as a monolith on the upstream face.—*R. E. Thompson.*

Tendency Toward Smaller Prime-Movers in German Water Works. S. BAER. Eng. News-Rec., 104: 329, February 20, 1930. An abstract of paper in Engineering Progress (Berlin) in October, 1929. During the past 25 years the tendency in water works plants in Germany has been to install an increasing number of pumps of such type as to require less space than that necessary for triple expansion pumping engines. This trend has been in spite of the advantages of high thermal efficiency and long life possessed by the older types of equipment. The most powerful pumping engine for municipal water supply in Germany, and perhaps in the whole of Europe, is the 3000-horsepower engine at Mülheim put in service in 1915, which has a capacity of 1,584,000 gallons per hour against a static head of 450 feet. The majority of the newer installations have been electrically-driven centrifugal pumps.—*R. E. Thompson.*

Federal and State Agencies Dealing with Water Resources. W. S. CONANT. Eng. News-Rec., 104: 321–3, February 20, 1930. An index is given of the authorities, both federal and state, in which is vested the control of water resources.—*R. E. Thompson.*

Improvements Effect Economies on the C. & O. Railway. R. N. BEGIEN. Eng. News-Rec., 104: 187–90, 1930. Improvement of water supply and water supply facilities has been one of the outstanding projects which have shown full justification of the expenditures made. The number of treatment plants on the Chesapeake and Ohio system has increased from 14 to 46 since 1922. Approximately 55 per cent of the total amount of water used is now treated, practically all of the remainder being satisfactory without treatment.—*R. E. Thompson (Courtesy Chem. Abst.).*

Benefits of Proposed River Cutoffs Determined by Model. Eng. News-Rec., 103: 886–8, December 5, 1929. An illustrated description of tests conducted in the hydraulic laboratory of the University of Iowa on a model of the Des Moines River at Ottumwa to determine the flood protection benefits of proposed river cutoffs. This is probably the first attempt in the United States to determine in advance of actual field construction, by means of models, the benefits to be derived from the straightening of rivers.—*R. E. Thompson.*

Why the Mississippi Meanders. LLOYD B. SMITH. Eng. News-Rec., 103: 899, December 5, 1929. Brief discussion of the meandering of rivers, with particular reference to the Mississippi.—*R. E. Thompson.*

Hydraulic Experiments at the Bonnet Carré Spillway. W. B. GREGORY. Eng. News-Rec., 103: 817–8, November 21, 1929. Criticism of the design of the Bonnet Carré spillway of the Mississippi flood control plan.—*R. E. Thompson.*

Bonnet Carré Spillway Believed to be at Wrong Location. A. B. B. HARRIS. Eng. News-Rec., 103: 818–9, November 21, 1929. Criticism of location and design of spillway.—*R. E. Thompson.*

Government Must Pay Damages in Bœuf Floodway. Eng. News-Rec., 104: 60–1, January 9, 1930. Essential passages are given from decision rendered by Federal District Court at Monroe, La., in proceedings brought by landholder in the proposed Bœuf floodway. An injunction was granted restraining the building of the guide levees until provision has been made for compensating the owners of the land in the floodway. As the cost estimates on which the present project is based were made without including damage payment to landowners in either the Bœuf or Atchafalaya floodways, the decision, if sustained, means a great increase in costs and may necessitate complete reconsideration of the floodways planned, possibly including economic comparisons between wide and narrow floodways.—*R. E. Thompson.*

Mississippi Flood Control. LYTLE BROWN. Eng. News-Rec., 104: 227–31, February 6, 1930. A detailed discussion of the Mississippi flood control project, its principles and history, and of the major elements comprising the plan, together with suggestions of prospective changes.—*R. E. Thompson.*

Levee Building Operations. Introduction. T. H. JACKSON. Eng. News-Rec., 104: 232–3, February 6, 1930. A survey of construction conditions, methods, and plants. C. S. HILL. Ibid., 233–9. An extensive summary of present operations on the Mississippi project, in which the evolution of methods and equipment is set forth.—*R. E. Thompson.*

Pump Discharge Headers and Piping. PALOTAI ARMIN. Eng. News-Rec., 103: 942–3, December 12, 1929. A discussion of the paper of F. G. CUNNINGHAM, in which is submitted a scheme for replacing the usual header and pipe connections at a pumping station with a small elevated tank, if there is no elevated water reservoir near the pumping station. Comments by F. G. CUNNINGHAM are also given.—*R. E. Thompson.*

Accuracy and Economy of Proposed Concrete Tests Questioned. ZARA WITKIN. Eng. News-Rec., 104: 295, 1930. Criticism of test suggested by GRIESENAUER (cf. C.A. 24: 481).—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Water Works Improvements Reduce Costs at Evansville. H. F. LUTZ. Eng. News-Rec., 103: 997–8, December 26, 1929. Coal consumption at Evansville, Ind., has been reduced from an average of 4.11 tons per million gallons of water pumped in 1926 to 1.90 tons in September, 1929. A new 20-million-gallon storage reservoir on elevated ground has made it possible to operate the pumps at high efficiency at a practically constant rate with only one boiler in service instead of two, as when the pumping rate had to be varied with the consumption rate. Other improvements include replacement of inefficient natural-draft stokers with forced-draft chain-grate stokers, installation of a zeolite softener for treating the boiler feed makeup water, provision of boiler room appurtenances and reconditioning of the two 10-m.g.d. vertical triple-expansion pumping engines installed in 1897, the duty of which had dropped to less than 50 percent of the original. These engines have been in almost continuous operation for approximately 32 years. Another improvement is a new scheme

of wash water pumping. The original steam-driven centrifugal units were not entirely satisfactory and later the wash water was drawn directly from the high pressure main. The new unit consists of a hydraulic turbine, using and discharging into the wash water line 1500 gallons per minute from the high pressure main, direct-connected to a centrifugal which pumps approximately another 1500 gallons per minute from the clear well into the wash water line. This arrangement gives the same amount of wash water at half the fuel cost and with half the required high service pump capacity. A change is also being made in the low-service pumping equipment which lifts the water from the Ohio River to the filter plant. Electrically-driven pumps are being substituted for steam turbine-driven units, this being found more economical than construction of a new station and intake system, the space available not permitting an increase in capacity with the old equipment. The cost of the improvements was estimated at $1,195,000 and actual cost will probably be somewhat less.—*R. E. Thompson.*

Shunt System of Operating Filtered Water Reservoirs. EUGENE A. HARDIN. Eng. News-Rec., **103**: 1011–5, December 26, 1929. In many plants where the filters discharge into reservoirs there is a considerable loss of power due to the fact that the water, in entering the reservoir, drops over a weir or other outlet device down to the level of the water in the reservoir. As the reservoir level falls during the day, when the stored water is used to augment the filter plant output during the peak demand, in many plants there would be a lowering of the suction head at the pumps of as much as 10 and possibly 20 feet. In large plants this loss of power is recognized as a source of considerable operating expense, and to overcome it the reservoirs are ordinarily kept at as high a level as possible. Thus the filter plants are required to follow closely the hourly demand, a method of operation which requires a larger filter plant than would be necessary if advantage could be economically taken of the reservoir storage. While on a program of enlargement, a plan was developed at Detroit, Mich., by which about three-fourths of this loss is saved. The saving amounts to an average of about 5 feet of suction head on all the water pumped at the Waterworks Park plant, representing a saving of approximately $15,000 per year at present pumpage and power rates. The plan adopted is that of delivering a considerable portion of the filtered water directly to the suctions of a majority of the high-lift pumps at a constant high level without passing it through the reservoir, while a few pumps draw from the reservoir. For flexibility, the number of pumps on the reservoir may be varied as desired. The two systems of suction conduits are cross-connected and check gates on this connection will permit water to flow from the reservoir should the water level in the direct conduit system fall below that in the reservoir. The daily demand rates at Detroit are comparatively uniform, hence only about 12 percent of the day's supply must be drawn from the reservoir to equalize the filtering rate throughout the day. On this basis it is estimated that 80 percent of the water filtered may be drawn directly from the plant, allowing for inefficiencies in operation. Since the reservoir is on a shunt parallel with the direct conduits, this system of operating between filter plant, filtered water storage reservoir, and high lift pumps has been named the "shunt reservoir system."

The method has been in use since February 24, 1929. Provision is being made in the design of the new plant under construction for operation on the shunt system. The existence of the problem solved by this system was first recognized and the general idea leading to its solution first conceived, by GEO. H. FENKELL, and the work was carried out under his general supervision.—*R. E. Thompson.*

Providing Oiltight Contraction Joint in Reservoir Lining. Eng. News-Rec., **103**: 1019, December 26, 1929. A brief illustrated description of the type of contraction joint employed in placing a 3-inch concrete lining in a 2,500,000-barrel oil reservoir. The lining was laid on a rolled-earth subgrade and had 6- by 6-inch wire-mesh reinforcing at the center of the slab. The floor was placed in alternate panels, 12 feet wide, and the joints were made with galvanized iron.—*R. E. Thompson.*

Heavy Construction on New Line for the L. & N. R. R. Eng. News-Rec., **103**: 916–9, December 12, 1929. Details are given of 4 tunnels, one more than 6200 feet long, comprising part of line being built through the Cumberland Mountains in Kentucky by the Louisville and Nashville Railroad. Two of the tunnels will be lined throughout with concrete.—*R. E. Thompson.*

Permanganate Titrations of Iron with Erioglaucin A (G) and with Eriogrün B (G) as Indicators. J. KNOP and O. KUBELKOVA. Z. anal. Chem. **77**: 125–30, 1929. From Chem. Abst., **23**: 3871, August 20, 1929. Excellent results were obtained in the permanganate titration of ferrous salt in MOHR's salt. With samples containing only 1 milligram of iron, using 0.005 N potassium permanganate, results accurate to within 0.5 percent were obtained.—*R. E. Thompson.*

The Water Works of Leipzig. H. SCHILLING. Gesundh. Ing., **52**: 337–40, 377–82, 1929. From Chem. Abst., **23**: 3998, August 20, 1929. Historical review.—*R. E. Thompson.*

Pollution of the Lahn River in Marburg. KAPELLER. Arch. Hyg. Bakt., **101**: 81–94, 1929; Wasser u. Abwasser **26**: 22. From Chem. Abst., **23**: 4987, October 20, 1929. The oxygen demand and oxygen content of water are good indications of sewage pollution. Other important tests are total bacteria and determination of ammonia.—*R. E. Thompson.*

The Estimation of the Phosphate Ion in Relation to Contamination of Sewage, River Water, and Swimming Pool Water. E. REMY. Arch. Hyg., **101**: 366–8, 1929. From Chem. Abst., **23**: 4988, October 20, 1929. The concentration of phosphate does not indicate the degree of contamination.—*R. E. Thompson.*

The Detection and Determination of Urea in Water and Its Decomposition by Bacteria and Chlorine. A Study of the Chlorination of Swimming Pool Water. HANS WETTE. Arch. Hyg., **101**: 222–33, 1929. From Chem. Abst., **23**: 4988, October 20, 1929. The amount of urea present gives no definite indication of the degree of contamination of the water of swimming pools.

but may be used to approximate the degree of purification realized during chlorination. The urea may be removed either through the action of free chlorine or through the action of bacteria.—*R. E. Thompson.*

The Effect of Sugar Factory Waste Water on Streams. MATSCHKY. Centr. Zuckerind., 37: 520–2, 1929. From Chem. Abstr., 23: 4988, October 20, 1929. The slight differences in the oxygen content of the water above and below the factory indicate little, if any, harmful effects.—*R. E. Thompson.*

Strength of Butt Welds Made with Metallic Arc. G. TOBO, Jr. Elec. World, 94: 387, 1929. From Chem. Abst., 23: 5137, November 10, 1929. Data are plotted for metallic arc-welded butt joints showing that: 45° is the best angle of bevel for a joint, strength decreasing with angle; single V joint is stronger than double V; strength of joint increases up to at least 1 inch thickness of plate.—*R. E. Thompson.*

City of Hamburg Water-Works. W. HOLTHUSEN and R. SCHRÖDER. Reprint from Industrie-Bibliothek 25. Verlag M. Schröder, Berlin. Wass. u. Abwass., 1929, 25: 6, 168. Historical account of the general management of Hamburg water supply from 1370, followed by a description of the Elbe Water Works built in 1893 and later enlarged, comprising the original works at Billwarder Island, the special filter works at Kaltehof and the pump works at Rothenburgsort. The water is pumped to settling tanks, after which aluminium sulphate is added as it flows to four settling reservoirs. It then flows through closed channels to the filter works and so to the pure water reservoir. Since 1923 chlorination has been added, the water being treated in the settling reservoirs and after filtering, the result being a practically germ-free water. A description of the works for underground water follows. A third reservoir was added to the Rothenburgsort works in 1926–7. The pumping plant at Rothenburgsort is described in detail and a complete bibliography of literature on the water works and bathing establishments of Hamburg is added.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Water and Sewage in the Rhine-Westphalian Industrial District with Special Reference to the Emscher and Lippe Companies. H. HELBING. Essener Heft, Kl. Mitt. Ver. f. Wasser-, Boden-, u Lufthyg., 1927, Supplement 5: 19. Description of development of Rhine-Westphalian industrial and mining region. The division of the district, growth of mining since 1840, output of coal from 1891–1925, water demand of the industries, and population of the different river districts are shown in charts and plans.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Economic Development and Technical Progress in the Hamburg Warm Water Bath Establishments. M. BAYER. Tech. Gemeindebl., 1929, 32: 8, 119. Reference is made to two articles on this subject by H. LÜHR (Veröff. d. Deutsch. Ges. f. Volksbäder, 8: 263). Hamburg has seven warm bath estab-

lishments with 11 swimming pools, 162 first class and 299 second class bath-tubs, and 157 shower baths. In 1928 pine baths were introduced and lately medicinal baths with massage have been added. In the summer months 14 open air river baths are also in use. Building costs of these establishments were about 5 M. per head of population. Cost at present day would be 100 percent more. Facilities supplied by Hamburg, in comparison with other great German cities, are, for the size of its population, very great. Supply of baths in homes is also increasing, 61 percent of new houses built having at least one bathroom. Experience has shown that in estimating the economic possibilities of any new bathing establishment only the population within 1–1½ kilometres should be considered, and peak-time requirements, such as of week-ends and holidays, must be allowed for. Lowness of price is naturally an advantage and here Hamburg is amongst the lowest in Germany while its grant from the Reich is also low. The three requirements of good swimming pool water are unexceptionable appearance, unexceptionable hygienic condition, and low price. Formerly the baths were cleaned by the addition of fresh water, stirring, and changing the water after about 2 days use. In spite of this the water became bacteriologically impure and very dirty. Experiments with sieve filters and closed coke reservoirs were made but the filters easily choked and the bacterial content rose. Hamburg was the first city in Germany to adopt the English circulating method, which by aëration and filtration made used waters suitable for re-entry into the bath. Aëration was found superfluous and for a time the purification plant consisted of two filter chambers, filled with 2-mm. sand, and a pure water collecting chamber. In 1914, alum treatment was added, but owing to lack of material during the war, this was adopted generally only in 1925. Instead of settling tanks, which would have been too expensive, double filtration is used, the preliminary filter having a bed only 20 centimetres deep, that of the chief filter being 1 meter. Maintenance of residual free chlorine in the outflow from the pool has been rendered possible by the turbidity removal, accomplished mainly in the first filter. Ammonia is added to form chloramine and suppress the chlorine taste and smell. Carbonic acid freed by the alum is neutralized with either lime water or soda solution after leaving the first filter and thus corrosion is prevented. The water is drawn off from the pool at the deep end and enters again, after purification, chlorination, and warming, under the surface at the shallow end. A suction cleaner is used to remove sediment, consisting mainly of hairs and threads. Every pool is visited daily and tested once a month for free chlorine, carbonate hardness, and hydrogen ion concentration, and, at times of greatest use, is bacteriologically and chemically analyzed.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Estimation of the Potability of a Water According to Its Chlorine Content. L. Gillet and C. Guilleaume. Rev. Universelle des Mines, December 15, 1928; Le Genie Civil, March 30, 1929, 320; Gesund. Ing., 1929, 52: 28, 521. If the content of chlorides (principally sodium, but may also include some potassium, calcium, and magnesium) be greater than from 3 to 6 p.p.m., it is generally a sure indication of pollution by living organisms and such a water

should be cut off from the supply, or at least carefully controlled.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

The Drinking Water Supply in Holland. W. F. J. M. KRUL and F. A. LIEFRINCK, Rapport. en. Mededeeling. v. h. Rijksbureau v. Drinkwatervoorziening. Mededeling No. 8. Great advance has been made in Holland in the distribution of water since the first waterworks were established at Amsterdam in 1853. In 1928, all the large towns, numbering about 70, and about 400 out of the 800 rural parishes possessed water supplies. Daily consumption per head, amounting to 98.5 litres, is low in comparison with England and America, because the industries mainly possess their own supplies of water. Most of the waterworks are publicly owned. In 1913 a new section for dealing with all matters relating to water supplies was established under the Public Health Department. A short survey is given of the hydrogeological conditions in relation to water supply. Ground water is obtained from the sand-dunes in the littoral region. Iron and manganese are frequently present and must be removed. Natural springs are very scarce and river water is largely used. All surface water is purified by sedimentation and rapid filtration. Amsterdam and the Hague have a dune ground water and Rotterdam, with Delft, Schiedam, etc. a surface river supply. Reference is made to two new purification plants, for river water at Zwijndrecht and for ground water at Zutphen. —*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Stream Pollution Problems in Michigan. WALTER A. SPERRY. Michigan Public Health, 18: 2, 28, February, 1930. Only 10 per cent of the entire population of the State of Michigan are equipped to discharge through sewage disposal arrangement. Sixty-eight per cent of the population discharge raw sewage directly into the lakes and streams. Only 38 communities have sewage disposal plants, and there are 96 communities that should have them. There are 322 major industries in the State that contribute to stream pollution and which offer special problems. Michigan has a stream control commission consisting of the heads of the Department of Health, Conservation, Agriculture and Highways, together with the Attorney General. The State laws make it possible to finance sewage disposal plants. The chief problem of the State is to arouse public sentiment to a point where officials will be elected who are willing to make the improvements. This article is a direct appeal to the public to save and conserve the State's water resources.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

River Pollution. H. McLEAN WILSON. British Medical Journal, 3595, 997, November 30, 1929. Although conditions today are greatly improved over those of thirty years ago, due to activities under the Rivers Pollution Prevention Act, there is yet much work to be done to compete with the ever increasing quantities of spent liquid from developing industries and denser populations in the valleys. It is recommended that all communities affected by polluted streams apply to the Ministry of Health for permission to form a Rivers Board,

with power to control pollution of the stream to its source. Likewise, that sanitary districts be formed to centralize treatment plants, and that amendments be made to the existing laws governing admittance of industrial wastes to public sewers.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Sewage Disposal Practice in Europe. CHARLES G. HYDE. California Sewage Works Journal, 2: 1, 42, 1929. In Great Britain the condition of the streams is regulated by the Ministry of Health. The Thames River was cited as a splendid example of river control. In this drainage area there is a population of 620 persons per square mile. The river is used as a source of water supply, for bathing, boating and for discharging treated sewage effluent. For many years the typhoid fever death rate in the metropolitan district of London has been one or less per 100,000. When water supplies are derived from streams the burden of purification relative to bacteria, is placed upon the water taker. Chlorination of sewage effluents is rarely undertaken in Great Britain or on the Continent.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Preliminary Purification of Polluted Water. LYLE L. JENNE. Public Works, 60: 12, 460, December, 1929. This paper is concerned with the improvement in turbidity and bacterial content effected by long-time sedimentation and filtration in either slow or rapid sand filters, as based upon the monthly results obtained over a period of three years at the four Philadelphia filter plants. The conclusions contained in the article are as follows: (1) all things considered, the writer believes that where possible the best method of pre-treatment of polluted water is plain sedimentation with a storage period of a week or more, using a coagulant for turbidities over fifty, or possibly starting the coagulation at a lower point if conditions warrant; (2) another advantage is the dissipation of almost all of any taste and odor that may be present in the raw water; although we have no quantitative data to support this conclusion; (3) this method, except for storm periods, requires practically no attention; (4) the objection in the case of large installations is the area required; (5) the advantage of the short sedimentation and preliminary filtration is conservation of space. The objections are the dependence upon a mechanical installation for operating and cleaning, and the requirement for constant operating attendance; (6) this system has much less value in the removal of taste and odor.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

The Reduction of Phenol in Water. H. BACH. Emschergenossenschaft. Essen, Germany, Gesundheits-Ingenieur, 46: 796, 1929. The author reports that experiments were conducted with a tank holding 210 liters of water and eight goldfish, in order to determine the rate of reduction of phenol and effect of the phenol content upon the fish. Each day ten liters of the water in the tank were replaced by ten liters of fresh water, and each day the phenol content of the water was determined. Whenever the phenol content reached 0 it was brought back to 10 mg. per liter by addition of phenol. After equilibrium had been established it was found that the phenol content of 10 mg. per liter was regularly reduced in from two to four days and that with the exception of one

fish which jumped from the tank on the first day of the experiment, there was no discernible effect upon their health. The above phenol reduction equals seven-tenths of a mg. of phenol per liter of water per day. The author considers this an astonishing reduction, and believes this gives some reason to conclude that in quiet or slowly flowing waters, assuming no sludge deposits, self-purification is more rapid than in rapidly flowing waters (?).—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Some Dangers and Difficulties of Small Water Supplies. C. J. H. STOCK. Surveyor, 76: 1975, 547, November 29, 1929. The difficulties of small water supplies are in their high relative cost, in the restriction of choice as to source and in the uncertainties existing as to the quality of water obtainable from available sources. The dangers of such supplies are illustrated by three experiences of the writer, in which he found the water supplies of a large country house, an institution and a farm contaminated as the result of previously unrecognized defects in each respective system.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Purification of Water Supply of East Bay Municipal Utility District. JOSEPH DECOSTA. Public Health News, Public Health Center, Oakland, Calif., 8: 1, 2, January, 1930. A description of the steps taken to deliver a safe water to the consumers of the East Bay Municipal Utility Districts. These are vigorous sanitary control of the watershed; storage, filtration, sterilization by chlorination and complete laboratory control. The article is a popular treatise written for the layman.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Municipal Water Supplies in Illinois. W. D. GERBER. Illinois Municipal Review, 9: 1, 29, January, 1930. The Illinois State Water Survey offers municipalities and industries in that State, without cost, services of the nature of investigation and research covering all phases of water supply activities, except as to bacteriological quality. The service usually consists of a preliminary report on the type of supply that can be secured, together with information on the quality and quantity that has been found in the neighborhood. If the supply is to be obtained from wells the report may give the depths at which various aquifers are likely to be encountered, recommendations relative to the kind and placing of casing, etc. Later, analyses of water samples at the various aquifers may be made and assistance provided for making yield tests. From records of existing systems and from research work being carried on the Survey is making available extensive data relative to both ground and surface water supply development.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

The Importance of Determinations of B. Coli in the Supervision of Drinking Water. F. SIMONETTI. Igiene mod., 1928, 21, 353; Zbl. ges. Hyg., 1929, 20, 10. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature 3: 3, 84, March, 1930. "The application of the estimation of the coli-titer to a water supply during pipe-repair work showed the superiority of this method over the bacterial count for deter-

mining impurities. For this purpose Neri's process with lactose fermentation was specially suitable. Bacterial count and coli-titer do not follow a parallel course. The method used was to add to the water 10 percent of concentrated Liebig bouillon, 10 percent of a 10 percent peptone solution, 10 percent of a 15 percent lactose solution, and 0.5 percent of an alcoholic 1 percent solution of phenol red. The mixture is divided in different quantities into test tubes and incubated. (Wass. u. Abwass., 1929, 26, 100.)"—*A. W. Blohm* (*Courtesy U.S.P.H. Eng. Abstracts*).

The Practical Value of Some Colorimetric Methods of Estimating the Coli-Titer in the Examination of Drinking Water Supplies. P. PERANTONI. Igiene mod., 1928, 21, 339; Zbl. ges. Hyg., 1929, 19, 724; Wass. u. Abwass., 1929, 26, 99. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 84, March, 1930. "Comparative experiments of the methods for estimating coli-titer in water of Parietti, Abba, Eijkman and Lacomme showed that concentration of *B. coli* took place most rapidly and certainly by Parietti's method. Abba's process gave equally good and more enduring results, while the other two methods were less reliable. For Parietti's process two solutions must be prepared (1) 96 cc. of 5 percent carbolic acid solution with 4 cc. hydrochloric acid, and (2) concentrated Liebig bouillon, i.e., 1,000 cc. water, 100 grams peptone, 100 grams meat extract, 50 grams salt, boiled and then neutralised. 10 percent of the Liebig bouillon and 1 percent carbolic solution are added to the water and the mixture divided into test-tubes in amounts of 55.5, 11.1, 5.55, and 1.11 cc. Smaller quantities of the water (0.2, 0.4 and 0.8 cc.) can be used with about 10 cc. unconcentrated Liebig bouillon and 0.1, 0.2 and 0.3 cc. carbolic solution. After 24 and 48 hours these are seeded out on lactose special medium."—*A. W. Blohm* (*Courtesy U.S.P.H. Eng. Abstracts*).

Hygienic Experiences with Water Supplies during the Frost Period of the Winter of 1928–29. KRUSMANN and BRUNS, H. Gas-u. Wasserfach, 1929, 72, 1046. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 70, March, 1930. Gives an account of the temperatures and conditions of cold experienced in different parts of Germany during the winter 1928–29. Water works difficulties were especially great in cases where the supply came from naturally or artificially filtered surface water as in the Ruhr Valley, where the water, collected in seepage galleries or wells, is very largely river water reaching the underground gravel through the fine sand floors of "concentration pits." In the Ruhr works, chlorine to 3 to 5 times the normal amount had to be added. In addition to insufficient filtration, another cause of this demand was found in the settling out of yellow crystals of chlorine hydrate. The frost destroyed the self-purifying power of the river even in the Hengstey reservoir and definite chlorphenol tastes appeared. One works dealt with the trouble by adding ammonia solution before chlorination.—*A. W. Blohm* (*Courtesy U.S.P.H. Eng. Abstracts*).

Purifying Water. MUCHKA. B.P. 316,965; Ill. Off. J. Patents, 1929, No. 2124, 5384. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 75, March, 1930. "An apparatus for the removal from chlorinated water before dechlorination of injurious substances, the more injurious, such as iron, being separated before the less injurious, such as manganese. The chlorinated water passes through a bed of material which separates suspended matter and iron, and is then passed to a bed of pyrolusite or other material which will remove manganese. On leaving this bed, it is collected in pipes and passed to a dechlorinating filter of active carbon. Any of these filters can be by-passed. A diagram of the apparatus is given."—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Water Purification by Electricity. HEILMANN. Gesund. Ing., 1929, 52, 136; Gas-u. Wasserfach, 1929, 72, 1007. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 75, March, 1930. "A description of the electric process of the Siemens-Electro-osmosis Co., Ltd. (Siemens-Elektro-osmose G.m.b.H.) by which the salt content of water can be separated wholly or in part. The apparatus is worked by direct current of 60 to 220 volts and consists of ten 3-cell systems. The water to be purified enters the middle cell of the first system and is syphoned from each middle cell to the next. One hundred litres of water, according to composition, require 1.5 to 3.5 kilowatt-hours."—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

Field Chlorination of Water Mains. J. H. STROHMEYER. Surveyor, 76: 1960, 147, August 16, 1929. The chlorination of old and new water mains is the most effective means of destroying bacterial life therein. Often, impurities remaining in newly laid pipes may cause serious danger. The three steps in chlorination of mains are the charging of the mains, flushing and chlorination. The chlorinated water is allowed to remain 24 hours after which the main is thoroughly flushed and placed in service.—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

The Detection of B. Coli in Drinking Water Supplies. F. NERI. Igiene mod., 1928, 21, 328; Zbl. ges. Hyg., 1929, 19, 724. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literaure, 3: 3, 84, March, 1930. "The author's method for the estimation of the coli-titer is intended to avoid the use of neutral red, as many pure coli stocks do not alter this dyestuff. Further, the usual peptone broth is replaced by Liebig broth. Lactose is used as sugar. The water (200 or 500 cc.) is converted, by the addition of corresponding amounts of 10 percent peptone solution, 5 percent salt solution, 10 percent meat extract solution and 15 percent lactose solution, into a nutrient solution with 1 percent peptone, 1 percent meat extract, 0.5 percent salt and 1.5 percent lactose. Phenol red makes the best indicator. The liquid is divided in suitable quantities into test-tubes and incubated."—*A. W. Blohm (Courtesy U.S.P.H. Eng. Abstracts).*

The Application of the Venule for Bacteriological Examination of Water. F. W. BACH. Cbl. f. Bakt. etc., I, 1929, 3, 156. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 84, March, 1930. "The Behring-Venule, an instrument for the sterile reception of liquids, is specially applicable to the bacteriological examination of water, and can be used without alteration for taking samples near the surface. For use at greater depths, the instrument is fixed inside a hollow brass cylinder which can be lowered on a cord. A hook encircling the glass tube above the hollow needle of the Venule is attached to a lever arm on the brass cylinder also worked by a cord from above. When the apparatus has been sunk to the required depth, the weight of the brass cylinder is allowed to hang from the lever cord so that the hollow needle is pulled to the side and water is sucked in. When the lever cord is loosened and the needle returns to the perpendicular, no further liquid enters. The self-closing of the Venule protects the sample until examination is possible."—*A. W. Blohm* (*Courtesy U.S.P.H. Eng. Abstracts*).

Transparency and Clearness of Water. A New Apparatus for Determining the Degree of Transparency. F. KERL. Wasser u. Gas. 1929, 19: 13, 719; Wass. u. Abwass., 1929, 26: 3, 80. Cylindrical glass jar, 120 cm. high and 5 cm. diameter, enclosed in a metal pipe is provided near its base with side outlet into graduated glass vessel. An electric lamp is housed in metal case below the jar; between them is cobalt glass plate on which is fixed written test. Water is let out of cylinder into graduated vessel until test can be clearly read.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Estimation of the Degree of Turbidity of Water. H. ILZHÖFER. Arch. f. Hyg., 1929, 101: 1, 1; Wass. u. Abwass., 1929, 26: 3, 79. Description of KISZKALT's photometric method. Light of incandescent lamp falls through a column of water of variable height onto paper. Resulting illumination is compared with that obtained with pure water. With water height of 200–400 mm., fine degrees of turbidity can be measured. Results agree with measurements of OLSZEWSKI and ROSENMÜLLER's turbidimeter.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Paterson Turbidimeter. D. J. MIDDENDORP. Gesund. Ing., 1929, 52: 24, 426. Author describes method adopted for measuring turbidity in water several metres deep, when existing simple apparatus failed and it was desired to avoid complicated manipulation. If two plane mirrors almost parallel, face each other and a light is introduced between them, the images will be cylindrically disposed about the line of intersection of the mirrors as axis. If angle between the mirrors, radius of cylinder, intensity of light, and light absorption of surfaces are constant, turbidity of the medium can be determined by counting the number of visible images. Practical experiments were made with a tank with 2 mirror sides slightly inclined. Lamp was placed behind hole in back of one mirror while similar hole in back of other mirror served

as eye-hole. Liquids of standard turbidities were introduced and number of visible reflections counted for each degree of turbidity. To simplify counting, a movable screen was introduced whose position was recorded by pointer on scale. This screen is placed so as to touch, but not conceal, last visible image; pointer will then show the number of visible images and also the corresponding degree of turbidity. For coloured liquids, colour filter can be inserted in front of light, if scale is adjusted. Apparatus is suitable for insertion in mains, enabling turbidity of running water to be read at any moment. The Paterson Engineering Company of London, England, have taken over patent and production.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Investigations of the Most Suitable Simple Method of Analysis of Drinking Water. J. KABELIK and H. KABELIKOVA. Thomayers Samml. med. Vortr. u. Abh., Prag, 1927, **142**: 1; Cbl. fur Bakt., Parasitenk., und Infektionskrankh., Referate, 1928, **90**: 139. Survey of the literature on hygienic examination of well waters, with criticisms and suggested simplifications. Possibility of detecting phosphates and other salts by micro-biological methods is suggested. Organic matter may be estimated by simple permanganate titration. Literature on bacteriological examination is very fully discussed with special attention to differentiation of *B. coli* and *B. aërogenes*. In water with 10 percent ox-gall added, incubated at 38° for 24 hours, *B. coli* increase beyond other bacteria and can be detected as typical colonies. A special carrying vessel for samples to be tested is recommended.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Biology of Norwegian Lakes. Nature, 1929, **124**: 73. T. BRAARUD, B. FÖYN and H. H. GRAN. Norske Videnskaps-Akademi i Oslo, I. Mathem. Naturvid. Klasse 1928, No. 2. Report on the plankton in several lakes in East Norway in September, 1927, and in the Hurdals-See during 1926. Temperature, oxygen content, hydrogen ion concentration, and distribution of the plankton were investigated at different depths in the Hurdals-See from May to October, 1926, and in the other lakes in August and September, 1927. Amount of plankton varied much in the nine lakes examined, that of the Haugatjern being as much as 100 to 1000 times greater per surface unit than that of any of the other lakes. This lake was distinctive in having large masses of plankton occupying the opaque upper layers, a strong oxygen deficit at depths below six metres, and definite differences in hydrogen ion concentration between upper and deeper layers. Such conditions can only be explained by strong food stream from land. Renewing of plankton food must come either from upper layers, by supply from land, or by vertical circulation from below. In shallow lakes, there is daily vertical circulation owing to warming of bottom by solar radiation, but in deeper lakes circulation is much slower. Differences in richness of the plankton can probably best be explained by differences in circulation of foodstuffs. This is most rapid in shallow lakes which are also richest in plankton. The species taking part in mass production are few.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Analysis of Drinking Water. A. Kroulik. Cas. lek. ces. 1927, 1789; Cbl. für Bakt., Parasitenk., und Infektionskrankh. Ref. 1928, **90**: 5–6, 140. Recommends double-walled metal cylinders with ammonium nitrate between the walls for preserving flasks containing water samples for bacteriological tests. To avoid liquefaction of peptone-gelatine plates by water bacteria, gelatine should be mixed with peptone-agar immediately before pouring and plates should be placed in circular zinc coolers attached to water tap. Author distinguishes lactose, glucose, and saccharose by their action on the Bersiekow medium and differentiates, by appearance of colour reduction, between four types of *B. coli:—B. coli typicum* and *atypicum* and *B. paracoli typicum* and *atypicum*. With Parielli test combined with method of isolation proposed by author, purity of colonies and agreement with Ficker-Partis' test can be achieved.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

A New Type of Plankton Sieve. E. Naumann. Z. für wissenschaftl. Mikrosk., 1924, **41**: 351; Cbl. für Bakt., Parasitenk., und Infektionskrankh. Abt. II, 1928, **75**: 291. Description of new plankton sieve which collects the material on small surface in little water. Filtering surface lies at side of vessel and under it is impermeable floor sloping to outlet. By withdrawing a piston in outlet canal the concentrated sample flows out.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

I. Thioporphyra Volutans: A New Genus of Sulphur-Bacteria. II. The Sulphur-Bacteria as Aids in the Study of Polluted Waters. D. Ellis. J. Roy. Tech. Coll., Glasgow, December, 1926; Cbl. fur Bakt., Parasitenk., und Infektionskrankh., Abt. II, 1928, **74**: 273. In first part, account is given of structure and life-history of new genus of sulphur-bacteria. Suggestion is made that presence of sulphur is fortuitous and that sulphur bacteria are entirely saprophytic. In Part II is studied method of reproduction, which with sudden increase in rate of multiplication alters from fission to budding. By process of natural disintegration a proportion of the separated buds disappears, this being one of the natural means of preventing excessive numbers of such organisms in reservoirs. Use of *Beggiatoa alba* as indicator of sewage pollution is described.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

A New Process Employing Tannin for the Treatment of Boiler Feed Waters. K. Hofer. Glückauf, 1929, **65**: 541. Examination has been made of this process as used by Reschke in Essen. Colloids added to prevent scale usually produce much sludge. Reschke process eliminates this disadvantage; colloidal solution applied is very dilute and boiler water is recirculated through special chamber, where sludge is removed. Raw water and recirculating boiler water are led together into reaction chamber where any excess tannin present in latter reacts with calcium and magnesium salts in former, and sludge formed in this chamber and that carried from boiler settle out and are removed periodically. Hardness of raw water is thus reduced from 18° (322 p.p.m.) to

4.1° (73 p.p.m.). Water then passes through filter to another tank, where it is mixed with calculated quantity of tannin solution, prepared in special apparatus to ensure tolerably constant concentration, and then to boiler. This repeated circulation and tannin treatment prevent formation of scale and reduce the quantity of sludge in boiler to minimum. Brown colour of boiler water is due to tannin and not to iron. Although permanganate demand increased from 6.9 to 185.2 mg. per litre (i.e. oxygen consumed, from 1.75 to 46.3), tannin does not lead to foaming. Plant in which process was examined consists of eight boilers, each using 48 cubic metres of water daily. On opening boilers after from 3 to 4 months operation only a very thin scale was found, and this was easily removed.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Treatment of Boiler Feed Water. The Fuel Economist, 1929, 4: 441. National Electric Light Association of New York report on methods used by operating companies of central station field for treatment of boiler feed water. Twenty-four plants use evaporators, of which ten pre-treat water either with zeolite, or with coagulant. It has been found beneficial to pre-treat both condensate and make-up. Three companies use zeolite and find it satisfactory, despite minor operating difficulties. Nine plants, whose feed water contains but little incrustant, use chemical treatment. Four companies use no treatment. De-aëration, to prevent corrosion of evaporator condensers, is common. Two specific examples are quoted. The Columbia power station of Union Gas & Electrical Company, Cincinnati, treat Ohio River water with phosphate after preliminary lime and soda-ash treatment, aided by ferrous sulphate as coagulant. Disodium phosphate, at 50 p.p.m., added to condenser hot wells, successfully eliminates scale and also inhibits caustic embrittlement. The Detroit Edison Co. use zeolite system, with subsequent acid treatment to prevent caustic embrittlement. Scale is successfully eliminated, but corrosion troubles were experienced owing to low pH and presence of oxygen. Difficulty has been overcome by protective coatings of bitumastic paint in cold-water tanks and pipes and by recirculating sufficient blow-off water, which is caustic and converts free carbon dioxide and sodium bicarbonate into sodium carbonate, thus rendering water non-corrosive. About 6 p.p.m. of phosphoric acid is also added in order to precipitate a protective film of calcium phosphate on boiler metal.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Method for Preventing Boiler Scale Formation. F. Béguin. F.P. 654,963. Chem. Zbl. 1929, 2: 5, 619. Mixture of 80 to 90 percent calcined clay, 5 to 10 percent calcined lime, 2 to 5 percent wood charcoal, and 2 to 5 percent sawdust is shaped into plates, cylinders, cones, &c., and baked. In such vessels no hard boiler scale is deposited but incrustants are precipitated as fine dust.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Some Aspects of Water Conservation. R. A. Sutherland, Proc. Am. Soc. Civ. Engrs., 56: 1905, September, 1930. Water storage capacities for irriga-

tion and power purposes are given for many countries. World storage of water for irrigation is estimated at 69,000,000 acre-feet. Tested formulas are developed for preliminary study of merits of various storage and dam sites. Methods are also given for studying relative economy of different types of dams, where site admits of alternative types. Economic limits of specific capacity, or water stored per cubic yard of masonry in dam, are discussed in light of practical examples. Article is featured by many curves used in connection with the formulas.—*Isador W. Mendelsohn.*

Construction of La Ola Pipe Line, in Chile. W. B. Saunders, Proc. Am. Soc. Civ. Engrs., 56: 1547, September, 1930. Construction of pipe line to supply water from Rio La Ola to Metallurgical Plant of Andes Copper Mining Company of Potrerillos, Chile, is described in great detail with unit cost data and illustrations. The line is 32.3 miles long, of riveted steel pipe, varying in diameter from 22 to 36 inches, manufactured in the field at total cost of $84.20 per ton. Unique and outstanding features of this project, completed in November, 1926, are: (1) fabrication of the pipe in the field; (2) unusual methods of field transportation for construction materials; (3) construction of a number of inverted siphons under very light pressure heads; (4) rapidity with which construction work was accomplished; (5) low unit costs obtained under difficult conditions. Organization of necessary supervising staff, selection and training of large numbers of men in all departments, effects of climatic conditions at high altitudes, difficulties in getting together and organizing transportation facilities, and delay in receipt of necessary materials were notable obstacles encountered.—*Isador W. Mendelsohn.*

Tests of Broad-Crested Weirs. James G. Woodburn. Proc. Am. Soc. Civ. Engrs., 56: 1583, September, 1930. Results are given of 305 tests made during 1928–29 at University of Michigan on broad-crested weirs of various designs in rectangular wooden flume 2 feet wide. Crests varied in breadth from 10 to 15.5 feet, and in slopes and combinations of slopes from level to 0.085. Range of head was from 0.5 foot to 1.5 feet and of volume of flow, from 2.0 to 11.0 cubic feet per second. Advantages established by tests in favor of broad-crested over sharp-crested weir are: (1) Tail water can back up to elevation only slightly lower than water surface at down-stream end of weir without changing appreciably relation between head-water elevation and discharge. Moreover, if slope of weir is such that hydraulic jump can be made to occur on crest, nearly all the initial head can be recovered, still without changing the head-water-discharge relation; (2) Broad-crested weir, even when operating under considerable degree of submergence, requires measurement of head at only one point and is thus preferable to submerged sharp-crested weir and to Venturi flume, which require measurements at two points; (3) Possibility of causing flow at critical depth to occur at some predetermined point on crest at which depth can be readily measured. Discharge is then a simple function of depth, independent of confusing effects of velocity of approach. These tests showed that location of critical depth is affected by waves on crest. Conformation of these waves is, in turn, affected by volume of flow. With flows up to about 8 cubic feet per second, critical depth in a number of tests

occurred at change in grade, provided that slope of apron was not too steep; but, in other tests, waves caused position of critical depth to move short distances up or down stream. When flow was increased to more than 8 cubic feet per second, position of critical depth moved from 1 to 3 feet up stream from change in grade. Waves occurred at certain volumes of flow with every weir model tested in which part, or all, of crest was level. If the crest was given a slope sufficient to maintain flow without waves, critical depth was found to occur, as a rule, only at some point of the initial drop at entrance to weir, at which water surface sloped steeply and a small error in selection of point of measurement would cause considerable error in measured depth. Tests showed that there was no single location of critical depth for all volumes of flow. Some interesting relations, however, were brought out between design of weir, number of waves on crest, and location of critical depth. Much information was obtained in regard to weir coefficients and to factors affecting their variation. Coefficients as high as 3.08 were reached with a weir with rounded entrance followed by down-stream slope of 0.026. This slope of crest permitted formation of hydraulic jump and recovery of nearly all the initial head.—*Isador W. Mendelsohn.*

Supplemental Tests. Weirs with Apron Inclined Up-Stream and Down-Stream. ALEX. R. WEBB. Proc. Am. Soc. Civ. Engrs., 56: 1604, September, 1930. Results are given of 235 experiments supplementing WOODBURN's work on broad-crested weirs. The down-stream apron was set at slopes of 1 in 15.4, 1 in 24.8, 1 in 25.0, 1 in 25.5, and 1 in 46.4. Slope of up-stream apron was varied between 1 in 7.5 and 1 in 98.5. Heads ranged from 0.12 to 1.33 feet and discharges, from 0.22 to 9.33 cubic feet per second. Experiments show that, for flatter slopes, waves formed on up-stream apron and that location of critical depth changed with position of wave. This condition was less marked for the smaller discharges. Except for these very flat slopes, it was found that for each slope of down-stream apron there was a corresponding slope of up-stream apron, which caused critical depths for all discharges to lie in a vertical straight line near, but not necessarily above, apex of crests. Tests also showed: (1) Backing up of tail-water sufficiently to cause hydraulic jump to occur upon apron increases depth of water on weir; (2) values of coefficient, C, in the weir formula, $Q = C\ L\ H_a^{\frac{3}{2}}$, are very sensitive to small changes in slopes of aprons.—*Isador W. Mendelsohn.*

Stresses in Gravity Dams by Principle of Least Work. B. F. JAKOBSEN. Proc. Am. Soc. Civ. Engrs., 56: 1613, September, 1930. Theoretical investigation, in which Principle of Least Work was substituted for usual assumption of linear stress distribution on horizontal planes in gravity dams, leads to stress curve similar to that found in the English tests. Bending stresses, that is, vertical normal stresses due to water load, are found by usual method to be equal at up-stream and down-stream faces, while proposed theory gives considerably higher bending stress at upstream face and correspondingly lower stress at down-stream face. Maximum stress is found to be less than by usual method, but this is of no particular advantage, since compressive stress in up-stream face with reservoir full should exceed a definite minimum, and this

will generally be the determining factor in the design. Writer believes that stress distribution based on Principle of Least Work will more nearly approach true load stresses than results obtained by usual method.—*Isador W. Mendelsohn.*

Deficient Water Supply. T. R. Burke. Proc. Amer. Soc. Sanitary Engineers, 1928–1929, pp. 68–71. Habits of indifference to matters of water supply have been carried over from former ages. One-half-inch service pipe was first used in the days of the bored wooden log when we find the expression "equipped with strictly modern, running water." Then came the zinc-lined bath tub, the copper boiler, and other attributes of modern plumbing to increase the demand for water; but size of service pipe has not been increased proportionately. The real estate promotor guarantees water to every lot, regardless of sizes of pipes available, or of demand for water. When water supply fails, the plumber is blamed. The Board of Health should supervise such installations and condemn those which fail to maintain adequate pressure. Information is available making precise calculations of pipe sizes possible. It should be used. One-half-inch and five-eighths-inch services are unsatisfactory and three-quarter-inch services are seldom adequate. Nothing less than 1-inch should be used.—*H. E. Babbitt.*

Cross-Connections and Infection. T. J. Claffy. Proc. Amer. Soc. Sanitary Engineers, 1928–1929, pp. 71–74. Active campaign has been conducted by Public Works Department of City of Chicago against cross-connections, with coöperation of City Health Department. In test on a hospital plumbing system, a harmless dye was placed in a sterilizer on fourth floor and, when proper valves on water supply pipes were opened, the dye ran from the fixtures on every floor of the building. In general survey of hospitals, same form of equipment was found in them. Certain types of bed-pan sterilizers were found to be so arranged that cross-connection is formed between water supply and infected waste water.—*H. E. Babbitt.*

Cross-Connections. Wm. C. Groeniger. Proc. Amer. Soc. Sanitary Engineers, 1928–1929, pp. 75–97 and 158–166. Flushometer valves in water closets must be provided with break to prevent pollution of the water supply by siphonage. Cross-connections are made possible by many fixtures, in which possibility exists that water supply outlet may become submerged in waste water. Preventive and corrective measures are described and illustrated. Supply opening may be raised above waste water; installation of an "air-introduction" hole in water supply pipe to fixture will break the siphonage. High-up flush tanks are subject to pollution from dead vermin etc. and may siphon into water supply pipes. Contents of closet bowl may be forced back into low-down flush tank by efforts to force stoppage from closet bowl. Fixtures can be designed to overcome all of these objections. Test made by Bureau of Plumbing of State Department of Health of Ohio in 1926 revealed siphonage of waste water from various hospital fixtures into water supply pipes of hospital. Other hospitals in state are known to have similar equipment. All manufacturers of fixtures have not taken results of these tests in good

spirit. Many cities have revised their codes to prevent future cross-connections of this type.—*H. E. Babbitt.*

Cross-Connections. General Discussion. Proc. Amer. Soc. Sanitary Engineers, 1928–1929, pp. 97–108. Instances are cited of drawing of sewage through water supply pipes in hospitals; of dead rodents found in roof tanks and closet flush-tanks. Cross-connections have been found in plans for new hospitals whose plumbing has been designed to be in accord with building codes. Situation is disgusting and appalling.—*H. E. Babbitt.*

Progress in Elimination of Cross-Connections with Especial Reference to Hospitals. J. I. Connolly. Proc. Amer. Soc. of Sanitary Engineers, 1928–1929, pp. 234–240. Hospital superintendents, architects, engineers, and manufacturers are actively interested in methods of preventing water supply contamination in hope of preventing post-operative infections. More than 60 outbreaks of disease have been traced to this source of infection. Oil seepage from a neighboring garage prevented the opening of a new hospital. Leak from an ice-making machine forced back into city mains ammonia solution containing considerable copper dissolved from bronze parts. Domestic refrigerator discharged methyl chloride into water supply pipes. Siphonage breakers installed in hospital fixtures to prevent contamination of water supply proved inadequate in capacity. Water from hot-water heating system was forced into water supply, contaminating it. Other instances of contamination are cited.—*H. E. Babbitt.*

Pure and Wholesome Water. T. J. Dugan. Proc. Amer. Soc. Sanitary Engineers, 1928–1929, pp. 198–207. Pure water is hard to get for the automobile tourist. Review of reports of many health departments shows rural typhoid death rate greater than urban rate. Monetary loss from typhoid is estimated at $5,000,000. Quotations from health codes show proper methods for safeguarding water supplies, construction of wells, and placarding of safe supplies.—*H. E. Babbitt.*

The Chemical Precipitation of Humus Coloring Matters. C. P. Mom and O. H. van der Hout. Mededeelingen van den Dienst der Volksgezondheid in Ned.-Indie., 1, 1930. Account of tests at Experimental Water Purification Station, Manggarai, Java. Tests on the removal of color with alum, ferrous sulphate and lime, ferric chloride, and chlorinated ferrous sulphate. Satisfactory results were ultimately obtained through using chlorinated ferrous sulphate followed by addition of lime to neutralize the acidity. Ferric hydroxide is formed which brings down suspended organic matter and, at point of complete removal of iron, maximum organic matter is also removed and optimal pH is about 9.0. To improve taste, the water is oxidized with potassium permanganate and then filtered. Subsequent chlorination is impracticable because of strong tastes produced. Experiments are now under way to test biological methods of oxidizing the water. [These experiments are similar to those made at Elizabeth City, North Carolina, and reported in Journal American Water Works Association, 20: 467, 1928. Abstr.]—*H. E. Babbitt.*

Drilling by the Solid Tool or Cable Method. H. O. Williams. Johnson National Drillers' Journal, March, 1930. Brief description of the "standard," "solid tool," or "cable percussion" method of drilling, covering methods of drilling in rock and in unconsolidated formations.—*H. E. Babbitt.*

The Protection of Ground Water Supplies by Cementing. A. G. Fiedler. Johnson National Driller's Journal, March, April, May, 1930. Methods for preventing pollution of good ground water supplies by highly mineralized waters during construction of wells. Use of cement is most satisfactory method. Practically all methods of cementing wells have been developed in the oil industry but they can be applied to drilling of water wells. The methods of cementing described include: (1) dump-bailer method, either with, or without use of cement plugs; (2) tubing method, without plug, or with one plug; (3) casing method, with plug above and below cement, or without plugs; (4) asphalt sealing.—*H. E. Babbitt.*

Standard Method of Setting Screens. Anon. Johnson National Drillers' Journal, April-August, 1930. Series of articles describing acceptable methods of setting brass well screens. Discussions include: standard and bail-down methods of setting screens; development of wells with pumps, surge plungers, and compressed air; gravel-packed and gravel-walled wells; pulling screens; and rejuvenation of wells.—*H. E. Babbitt.*

Past and Future of Drilling Industry. O. E. Meinzer. Johnson National Drillers' Journal, June, July, 1930. The article takes the drilling industry from the early Chinese, through Egypt, Persia, and Europe to recent conditions in the United States. There is a résumé of present conditions and a prediction of the future, particularly devoted to methods of overcoming present difficulties.—*H. E. Babbitt.*

Theory and Practice of Developing Sand and Gravel Wells. Anon. Johnson National Drillers' Journal, October, 1930, and subsequent issues. General subject of development of wells in sand and gravel formations is discussed, beginning with outline of theory of sand screening and hydraulics of sand wells, continuing with subjects of back-washing, surging, and swabbing, developing with compressed air, and construction of gravel-walled and gravel-packed wells.—*H. E. Babbitt.*

Proper Preparation of Well Logs. Anon. Johnson National Well Drillers' Journal, October, 1930. There are as many different kinds of logs as there are drillers and engineers. The most important items in a log are pointed out and definitions of terms are proposed. A committee of engineers and geologists has been selected to examine logs and finally to prepare further standards. —*H. E. Babbitt.*

Jetting and Self-Cleaning Drilling Methods. H. O. Williams. Johnson National Well Drillers' Journal, December, 1930. General principles of various methods of well drilling are explained.—*H. E. Babbitt.*

Determination of Boron in Natural Waters and Plant Materials. L. B. WILCOX. Ind. Eng. Chem. (Analytical Ed.), 2: 358–61, 1930. Amount of boron usually found in water is about 5 p.p.m. Detailed description is given of distillation apparatus and of adopted modification of CHAPIN method. Copper, or special glass, apparatus is needed, since boron is a constituent of the usual laboratory glass. Method is quantitatively accurate for pure boron compounds not in excess of 5 mgm. Check analyses on natural waters differed by only 0.2 p.p.m. as a maximum. Method is practical for general use in water analysis.—*Edward S. Hopkins (Courtesy Chem. Abst.).*

The Nature of the Gram Compound and Its Bearing on the Mechanism of Staining. ALLEN E. STEARN and ESTHER WAGNER STEARN. Jour. Bact., 20: 287–95, 1930. Discussion of previous article relating to mechanism of GRAM stain in bacterial cell wall. Experiments conducted indicate that no new compound between dye of GRAM stain and iodine fixing agent is found as had been suggested. [These papers are of theoretical interest but do not present sufficient evidence to suggest change in technique of making the Gram stain.—ABSTR.].—*Edward S. Hopkins (Courtesy Chem. Abst.).*

Chemical Characteristics of Cement Pipe Lining. E. L. CHAPPELL. Ind. Eng. Chem., 22: 1203–6, 1930. Cement-lined water pipe after 50 years of continuous service in corrosive water was found to have been fully protected. No sand was used in the mix. Calcium content had decreased owing to replacement by ferric hydroxide, but without appreciable disintegration of coating, or impairment of its general protection to pipe. As would be expected, this exchange occurred more rapidly in hot water than in cold. Concrete lining of modern pipe (5 years old) showed calcium decrease of about 30 percent and increase in ferric hydroxide without break-down of coating. In laboratory experiments initial coating of aluminous cement containing 33 percent sand afforded complete protection upon prolonged immersion although practically converted to mixture of silica and ferric hydroxide. Base exchange property of cement lining and deposition of inert ferric hydroxide on exposed surface are important factors in pipe protection, quite separate and distinct from neutralization of free carbon dioxide by alkali present.—*Edward S. Hopkins (Courtesy Chem Abst.).*

The Initial Corrosion Rate of Steels. H. O. FORREST, B. E. ROETHELI and R. H. BROWN. Ind. Eng. Chem., 22: 1197–1200, 1930. This study shows that, as is true for ordinary steel, an oxide film is necessary for protection of chromium and chrome-nickel alloy steels. Their added resistance to corrosion is due to properties of films formed.—*Edward S. Hopkins (Courtesy Chem. Abst.).*

Progress Report on Waste Sulfite Liquors. GUY C. HAMMOND. Ind. Eng. Chem., 22: 1184–6, 1930. In method of treatment described, four sets of tanks in series are used, each set consisting of one reaction tank and one sedimentation tank. Addition of lime reagent to definite pH in tank set No. 1 results in a precipitate of calcium sulfite from which cooking acid is regener-

ated. Further lime reagent is added in set No. 2, increasing the alkalinity and precipitating the lignin. In sets No. 3 and No. 4 further quantities of same reagent are added as final stripping treatment. Effluent from set No. 4 is discharged into stream. Calcium sulfite is used as previously described and lignin is burned under the boilers. Effluent shows 75 percent reduction in 5-day bio-chemical oxygen demand, as compared with untreated waste.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

How Does Microscopic Plant Life Affect Filter Runs? L. A. Marshall. Water Works Eng., 83: 20, 1443, September 24, 1930. A group method of counting was used to determine number of organisms: data collected at Division filtration plant of Cleveland waterworks. Coagulant is alum. Filters are operated at 125-m.g.d. rate and to 9.0 feet loss of head. They are washed at 24½-inch per minute rate for three minutes. Two curves are given from which it can be seen that relation between decrease in filter runs and increase in microörganisms is approximately linear. They also portray the spring and fall peaks in plankton content. The diatoms are the characteristic organisms and *Melosira* unquestionably predominate and are blamed for short filter runs. Coagulation has a marked effect in reduction of microörganisms; from yearly average of 83 in raw water to 9 plus in water applied to filters. Increase in turbidity tends to reduce number of microörganisms going on to filters and to increase filter runs. Daily capacity of a filter plant is always equivalent to gross daily filtering capacity minus amount of wash water used during day. Failure to provide adequate wash water storage reduces net capacity and thus is apt to cause serious trouble during times of heavy draft. Writer feels that, for Cleveland, liberal use of wash water is cheaper procedure than trying to kill microörganisms with chlorine, or with copper sulfate.—*Lewis V. Carpenter*.

What the Courts Have Decided as to Water Works Taxation. Leo T. Parker. Water Works Eng., 83: 20, 1449, September 24, 1930. If a municipality furnishes large quantities of water outside city, higher court held the water system liable to taxation because it was not used either wholly, or exclusively, for public purposes of city. Knoxville bought a water system that supplied their own city as well as Park City. Park City sued for taxes on that part of the property within their city and Knoxville was held liable. In another case, the commonwealth tried to collect taxes on portion of property outside city of Richmond, but court ruled that, owing to fact that only 3 percent of revenue was collected outside city, the property should not be taxed. One community issued bonds to pay for water works improvements and, when bonds became due, issued negotiable bonds. These bonds exceeded legal limit, but higher courts sustained their legality, because they were replacement of legal series. The courts have in several cases upheld legality of transferring water works profits to sinking fund; but it is not mandatory. Court held that legislative acts made for convenience of certain municipalities are legal, provided there is nothing unethical. The water works of Kansas City, Kansas, was placed under board of five persons and courts held their actions as legally constituted.—*Lewis V. Carpenter*.

How a Small Plant Effected Saving in Pumping Costs. THOMAS W. WITTKORN. Water Works Eng., 83: 21, 1511, October 8, 1930. Media, borough supplying 6000 customers, reduced pumping costs from $28.10 to $9.25 per million gallons. Twin overshot wheels, each 9 feet in diameter and 8 feet wide, were geared to the same countershaft and drive a Deming Triplex pump. They utilize excess water from creek and have delivered 400,000 g.p.d. against a head of 115 pounds. Stand-by units were electrically driven and, on account of sliding scale, pumping cost for one month was $74 per million gallons. Old steam plant was revamped and is now used as stand-by.—*Lewis V. Carpenter.*

When is the Water Works Liable for Damages from Shutting off Supply? LEO T. PARKER. Water Works Eng., 83: 24, 1716, November 19, 1930. Courts have held that water company can shut off water for non-payment of bills and that consumers are not entitled to damages resulting therefrom. When water is shut off for repairs without first notifying consumer, courts have held water company responsible. In another case, where an instantaneous heater caused building to burn when water was shut off, courts held the water company not liable for damages, because company was not notified that heater of this type had been installed. Courts ruled that rates for sewers which were operated by a water company were not subject to public service commission rulings. In cases where an individual finances construction of a water line, permission must be obtained from this party before other services can be connected to it. An architect was hired to prepare plans for building to be built from $100,000 bond issue. Lowest bid was $135,000 and city decided not to build. Courts would not allow architect's fee, because plans were not within the agreed sum. —*Lewis V. Carpenter.*

Elevated Tanks Aid in Heavy Draught Periods at Milwaukee. HERBERT H. BROWN. Water Works Eng., 83: 24, 1719, November 19, 1930. City of Milwaukee installed 1,500,000-gallon elevated tank with bottom 120 feet from ground. After several weeks' experimental work it was decided to operate tank on time basis rather than on pressure differential. Valve was closed manually at 5 a.m. after tank filled, allowing water to remain in tank until 5 p.m. when altitude valve was opened and automatic operation of valve was allowed to remain in service to prevent overflow from tank. Solenoid-operated valve connected to electric time-switch is being installed to eliminate manual control. A 30-second opening of valve creates a 40-pound surge which produces a 6-pound rise at pump station 10 miles away. Changing time to 2½ minutes causes surge of from 6 to 14 pounds at tank. During past summer, maximum daily consumption increased 6.5 percent and maximum hourly consumption, 8.8 percent; but no complaints due to low pressures were registered.—*Lewis V. Carpenter.*

This Plant Combines Water Softening With Iron Removal. HARRY N. JENKS. Water Works Eng., 83: 25, 1775, December 3, 1930. Fort Dodge, Iowa, water company built rather unusual type of water works entirely from earnings from sale of water. Raw water is obtained from wells which flow 1 m.g.d. This flow is augmented by pumping to 3.5 m.g.d. Water has total

hardness of 550 p.p.m. and high iron content. Plant was designed for iron removal; yet so that, with little additional expense, softening could be added. Design was based on results obtained from experimental plant. New plant comprises aërator system, chemical agitation basin, chemical mixing tanks, settling basins and recarbonation chamber, and rapid sand filters. Aërator is of stream-flow type, particularly adapted to oxidize and precipitate iron. At same time H_2S is released and CO_2 lowered. Exhaust fan removes gases from the aërator which is in form of a cavern into which spectator can look as though through proscenium of a stage; it is lighted with colored flood lights. Spiro-vortex mixing is accomplished by specially designed circulating pump located in riser pipe between the tanks. This permits mixing velocities to be controlled, regardless of volume of flow through tanks. Settling basins are provided with Dorco traction clarifier mechanisms for continuous sludge removal. Recarbonation chamber is located between preliminary and final sedimentation units. There are four 1-m.g.d. filters. An unusual feature is the provision of infiuent and drain channels between filters and sedimentation basin, leaving but the wash water piping for pipe gallery, which was converted into clear well. Each two filters are operated by an electrically controlled panel board, eliminating the conventional operating table.—*Lewis V. Carpenter.*

Municipal Water Softening. CHARLES P. HOOVER. Water Works Eng., 83: 24, 1717, November 19, 1930. Works out the cost of softening water by soap for various hardness values. Cites results of tests at Columbus, where quantities of water actually used by two households were measured. Figures showed that consumer could afford to pay 5 or 6 times as much for softened as for unsoftened water, without reckoning time saved in laundry. Heat loss due to scale, $\frac{1}{50}$ to $\frac{1}{8}$ inch thick has been computed to be from 7 to 16 percent. American Railway Engineering Association estimates damage due to one pound of scale at 13 cents. Article briefly describes processes of softening and gives cost of construction and operation of softening plants.—*Lewis V. Carpenter.*

Pipe Line Weight When Full of Liquid. CHARLES V. JENKINSON. Power Plant Engineering, 35: 168–169, 1931. Charts, with sample calculations, are given for determining support needed for pipe lines carrying water and other liquids.—*G. L. Kelso.*

Can a Public Pool be Safe? CARL A. HECHMER. Municipal Sanitation, 1: 138–141, 1930. The Chevy Chase, Maryland, swimming pool owned by the National Capitol Natatorium Co. is 200 feet long and 100 feet wide with depth range from one to 10 feet. Water is circulated through purification system consisting of alum pot, pressure filter, and chlorinator. Filter is backwashed with pool water, doubly chlorinated. Free chlorine content of water is tested every two hours by *o*-tolidine method and is maintained at 0.4–0.5 p.p.m. in influent and at 0.1 p.p.m. in effluent. Soda ash is added with view to keep pH up to 7.6–8.0. Bacterial examinations made semi-weekly during season of 1929 showed 92 percent of samples to pass United States Treasury Department

Standard for drinking water. Daily cost of water was $11.90 and daily cost of providing safe water was $19.40.—*G. L. Kelso (Courtesy Chem. Abst.).*

Water Tunnel Shut off Despite Leaky Gate Valve. HERBERT H. BROWN. Municipal Sanitation, 1: 156, 1930. Leaky gate-valve in water tunnel at North Point pumping station of Milwaukee Water Works rendered necessary some other method of stopping flow. A "hydraulic bag" was constructed of rubber, covered with six layers of canvas. It was inflated with water to 30 pounds pressure and successfully performed its mission during a week that it was in use.—*G. L. Kelso.*

NEW BOOKS

Tropical Water Supplies. KELLER. Wilhelm Ernst u. Sohn, Berlin. 172 pp. 1929. An interesting book covering problems which persons in temperate climates are not forced to face. Water supply requirements in tropical countries vary widely. Daily needs in towns may be considered as 150 litres for whites and 50 litres for natives, based upon data collected by the author. Chemical composition of some African waters is also set forth. From a public health viewpoint, conditions are stated to be deplorable. This is substantiated by illustrations and death statistics. In the second chapter, consideration is given to hydrological matters. Rainfall and weather conditions, ground water and ground moisture, and their relationship to yield are discussed. Surface springs in hot countries are rare and the finding of ground water presents many difficulties. The author gives a number of indications which will help in this, such as the fact that the springbok may be found 50 to 60 km. from the nearest ground water. Twenty-two pages are devoted to a discussion of natural springs, artificial wells, like the tube wells in Abyssinia, galleries such as are found in Algeria and which have been used in Persia since ancient times, and underground reservoirs lying in subterranean hollows in the old land surface beneath the alluvium. Briefly, reclamation schemes in arid countries are discussed. One point brought out is that small isolated projects are of little practical benefit. Coupled with this, there is some space devoted to both high and low dams. In Bermuda, cisterns usually have a capacity of 30 cubic meters, the requirements of the natives being about 40 litres per day. For whites, the capacity should be about 200 cubic meters. The author expresses some belief in electrical control of rainfall in South-West Africa. After this, there is a section on purification, the processes advocated being sedimentation and filtration. Sections are given to physical, chemical, and bacteriological methods. The detailed procedures appear to be adequate. Disinfecting agents, particularly ultra-violet ray, are discussed. The last chapter is given to waterworks appliances, pumping, tanks, reservoirs and pipe lines.—*Arthur P. Miller.*

A Physico-Chemical Study of Scale Formation and Boiler-Water Conditioning. R. E. HALL, G. W. SMITH, H. A. JACKSON, J. A. ROBB, H. S. KARCH, E. A. HERTZELL. Carnegie Institute of Technology, Pittsburgh, Bull. 24:

1927, 256 pp. $2. Covers entire field of investigation which continued from 1922 to 1926. R. E. Hall, in introduction, summarizes procedure and results of investigation which was divided into five parts: (1) principles of boiler water conditioning; (2) solubility of calcium sulphate, barium sulphate, and calcium phosphate at boiler water temperatures; (3) relation of hydroxyl-ion to inhibition of corrosion; (4) non-condensable gases in steam; and (5) increment of soluble and insoluble salts in boiler waters. Bulletin is illustrated, tables of results are given, and each of parts 1 to 4 is supplied with bibliography.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*